BASELINE ASSESSMENT OF THE BATS OF DEVILS RIVER STATE NATURAL AREA, DAN A. HUGHES UNIT, VAL VERDE COUNTY, TEXAS

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ABSTRACT

A survey of bats was conducted from July 2013 to December 2014 to determine the species diversity and community composition at Devils River State Natural Area, Dan A. Hughes Unit, (DRSNA-DHU). Traditional and acoustic techniques for sampling bat species were used to detect species at six stationary sites and along a 12.9-km transect route across DRSNA-DHU. There were a total of 24 transects driven, 14 nights of stationary recording, and 10 nights of mist netting during the course of the study. Using information from acoustic recordings (analyzed manually and via software analysis) and mist net captures, 13 species were documented at DRSNA-DHU: *Antrozous pallidus*, *Corynorhinus townsendii, Lasiurus borealis, Lasiurus cinereus, Lasionycteris noctivagans, Mormoops megalophylla Myotis velifer, Myotis yumanensis*, *Nycticeius humeralis, Nyctinomops macrotis, Parastrellus hesperus, Perimyotis subflavus, Tadarida brasiliensis.*

TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Bats are common in the United States and can be found in most regions, although they are most abundant in the southwestern states (Ammerman et al. 2012). The Chihuahuan Desert ecoregion (Trans-Pecos) in far West Texas, with its topographic pattern of high mountains and desert lowlands, supports more kinds of bats (27 species) than any other part of the state (Ammerman et al. 2012). The Edwards Plateau also maintains a high diversity of bats, chiefly cavern-dwelling species that inhabit the numerous caves of this region, often in staggering numbers. The diversity and abundance of bats is lower in the northern, eastern, and southern areas of the state, where topographic heterogeneity is low and caves are uncommon (Ammerman et al. 2012).

Many bats found in Texas are seasonal residents of the state, and migrate to Mexico for winter. The best known of these is *Tadarida brasiliensis*, which arrives in spring, completes its cycle of raising young, and then departs in fall. These bats winter in Mexico, and migratory moves of up to 1,300 km have been recorded (Villa-R. and Cockrum 1962). Many species of *Myotis* are either less active during the winter months or migrate out of the state during that time. Other migratory species that occur in Texas include tree-dwelling species such as *Lasiurus cinereus*, *Lasiurus borealis,* and *Lasionycteris noctivagans,* which move as far northward as Canada in the summer months and then southward to the southern United States and Mexico in winter (Hill and Smith 1984; Fleming and Eby 2003). These bats have been recorded throughout the year in Texas during both the northward and southward phases of their migratory cycles (Ammerman et al. 2012).

Journal of Mammalogy

Study Area. — A biological survey of mammals, birds, reptiles and amphibians for Devils River State Natural Area was conducted from 1998-2001 (Brant and Dowler 2001). That study addressed the vertebrate fauna of the 7,138-hectacre area now termed Devils River State Natural Area – North Unit, or Del Norte Unit. In 2011, 7,639-hectacres were added and this property has been referred to by several names: Devils River State Natural Area – South Unit, Big Satan Unit, Devils River Ranch, and, most recently, Dan A. Hughes Unit (DRSNA-DHU; Texas Parks and Wildlife Department 2012). Because DRSNA-DHU is a larger area with much greater frontage along the Devils River that will someday be open to the public as a recreational natural area, a similar baseline assessment of this site was warranted. The Devils River State Natural Area, Dan A. Hughes Unit is situated along a 16.2 km stretch of the Devils River northwest of Slaughter Bend in Val Verde County, 2 km north of Del Rio, Texas (Fig. 1). The property is accessed off of Miers Road, West of US Highway 277. Because this area is at the juncture of the Chihuahuan Desert, Edwards Plateau, and Southern Texas Plains ecoregions, it is an important location for understanding the biogeographic and faunistic relationships among southwestern Texas vertebrates. The preserve likely supports at least 86 species of mammals including 17 species of bats (Schmidly 2004; Ammerman et al. 2012).

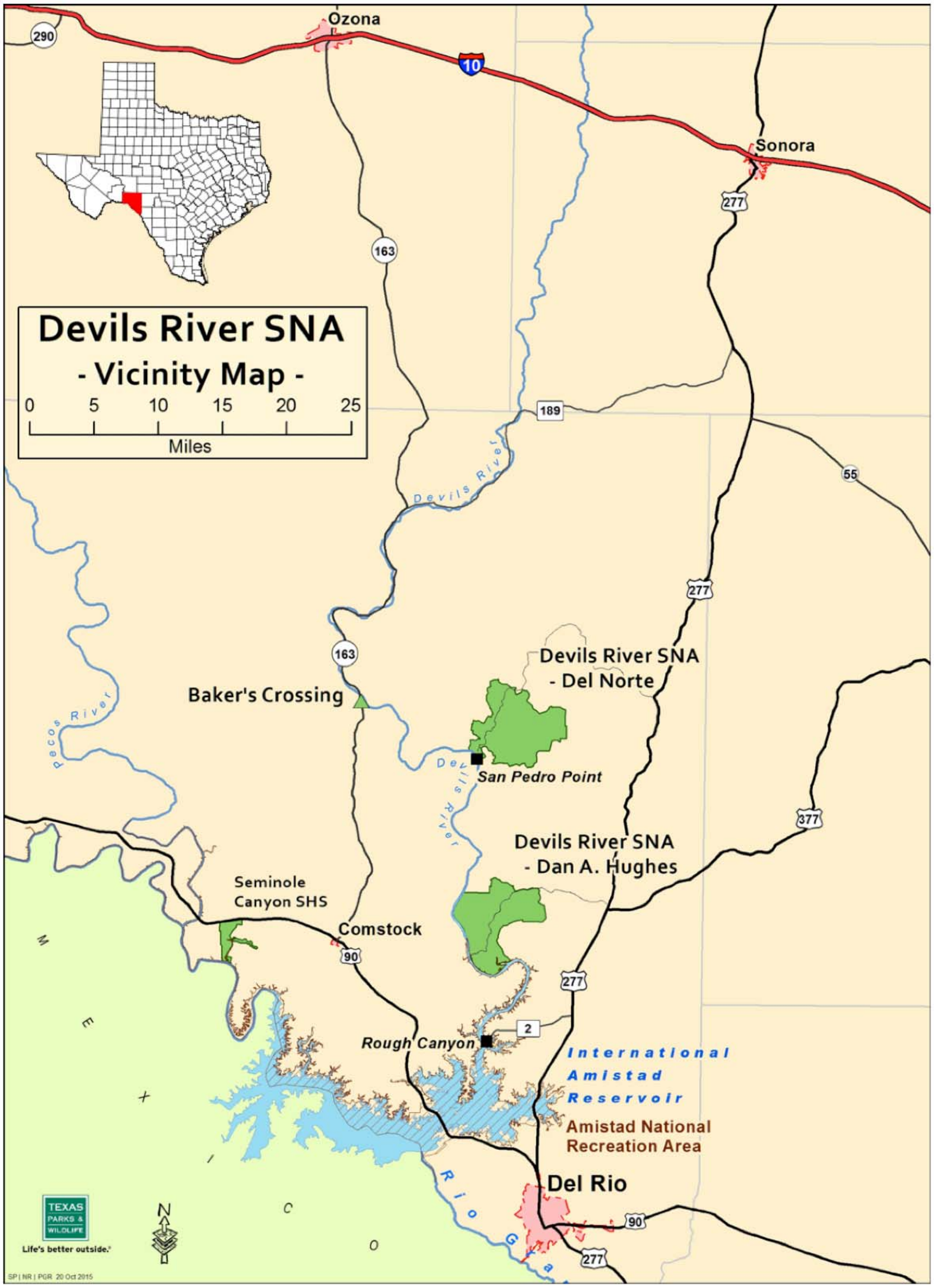

FIG. 1.—Map of Val Verde Co. and surrounding area in South Texas, showing the North (Del Norte) and South (Dan A. Hughes) units of the Devils River State Natural Area (DRSNA), north of the International Amistad Reservoir and Del Rio, Texas (Texas Parks and Wildlife Department 2015).

Because they have either been documented in Val Verde county or based on current distribution maps, the following species of bats could possibly occur at DRSNA-DHU: *Mormoops megalophylla, Diphylla ecaudata, Myotis yumanensis, Myotis velifer, Lasiurus borealis, Lasiurus cinereus, Lasiurus seminolus, Lasiurus xanthinus, Lasionycteris noctivagans, Parastrellus hesperus, Perymyotis subflavus, Nycticeius humeralis, Corynorhinus townsendii, Antrozous pallidus, Tadarida brasiliensis, Nyctinomops macrotis,* and *Eumops perotis* (Schmidly 2004; Ammerman et al. 2012).

Advances in the design of acoustic monitoring equipment have provided means to ameliorate many of the problems associated with capture methods (Williams et al. 2006), such as the inability to sample a large area relative to that used by free-flying bats (Dixon et al. 2014). Today, bat detectors are more portable than ever. They range in size from large units the size of a car battery to smaller, handheld units the size of a silver dollar that plug directly into a cell phone or tablet (Ammerman et al. 2012). These detectors consist of an ultrasonic microphone and a converter, which contains circuitry that transforms the ultrasonic calls of bats into a lower frequency within the range of human hearing (Limpens and McCracken 2004) and allow spectrographs of calls to be easily displayed and analyzed (Parsons and Szewczak 2009). Current technological advances in acoustic sampling devices provide opportunities to identify free-flying bats (Fenton and Bell 1981) and allow reliable identification of most species of bats thus far examined (O’Farrell and Miller 1999; O’Farrell et al. 1999; Ochoa et al. 2000).

When determining presence/absence of many species of bats, acoustic detection has proven to be more effective than capture methods (O’Farrell and Gannon 1999). Acoustic monitoring also provides a number of advantages including the following: a less-intrusive method of collecting activity data for individual species of bats; the ability to detect free-flying bats outside the reach of traditional sampling methods, the potential to record passively over the period of an entire night, and the potential to sample multiple locations at the same time with minimal effort (Williams et al. 2006). Bat detectors are also relatively easy to set up. They can sample a wider variety of habitats than traditional methods and require no direct contact with bats (O’Farrell and Gannon 1999). However, like all sampling methods, acoustic monitoring of bats has its own set of biases. Some species of bats are identified more easily than others (O’Farrell et al. 1999). While some bats (e.g., *Macrotus californicus* and *Corynorhinus townsendii*) produce vocalizations of low intensity making them problematic to detect at distances greater than 15 m, other bats produce high-intensity vocalizations that may be detected at distances greater than 100 m (Williams et al. 2006). Although species identity can potentially be identified, acoustic information cannot provide sex, age, or reproductive status (Williams et al. 2006). It has been shown that a combination of capture devices and acoustic detection can increase the accuracy of species verification within local bat assemblages (O’Farrell and Gannon 1999; Dixon et al. 2014).

The principal purpose of this study was to systematically survey and document the species of bats present at DRSNA-DHU using both capture methods and acoustic monitoring devices with emphasis on establishing baseline information on the taxa present at the site. I hypothesized that there would be seasonal fluctuation in species’ presence/absence at DRSNA-DHU. Using a consensus approach to determine presence/probable absence of bat species, I was able to document the species of bats present at DRSNA- DHU. I was able to do so by using information from acoustic recordings (analyzed manually and via software analysis) and captures.

MATERIALS AND METHODS

Study Design. —The fieldwork for this study was conducted on a monthly basis for a total of 17 months from July 2013 through December 2014 at DRSNA-DHU in Val Verde County, Texas. A 12.9-km transect route and six stationary sites were sampled (Fig. 2). To inventory bats, I used a combination of capture and acoustic methods. Differences in bat species detectability when using acoustic and capture methods are well documented and necessitate using a complementary combination of acoustic and capture methods to yield a more complete inventory of bat species (Kunz and Brock 1975; Murray et al. 1999; O'Farrell and Gannon 1999; Flaquer et al. 2007). For the purpose of determining seasonal fluctuation in species' presence/absence at DRSNA-DHU, I divided my research study period into six seasons by date and time as follows: summer 2013 (05:04 21 June 2013 – 20:44 22 Sept 2013), fall 2013 (20:44 22 Sept 2013 – 17:11 21 Dec 2013), winter 2013 (17:11 21 Dec 2013 – 16:57 20 Mar 2014), spring 2014 (16:57 20 Mar 2014 – 10:51 21 June 2014), summer 2014 (10:51 21 June 2014 – 02:29 23 Sept 2014), fall 2014 (02:29 23 Sept 2014 – 23:03 21 Dec 2014). These times were computed by the Astronomical Applications Department of the United States Naval Observatory (2015).

Traditional sampling (mist netting). —Mist nets are the most commonly used devices for capturing flying bats (Hayes et al. 2009) and offer many advantages to the collector such as: the ability to take bats in large numbers, the ability to obtain species otherwise difficult to collect, and the ability to release alive the captured individuals (Ammerman et al. 2012).

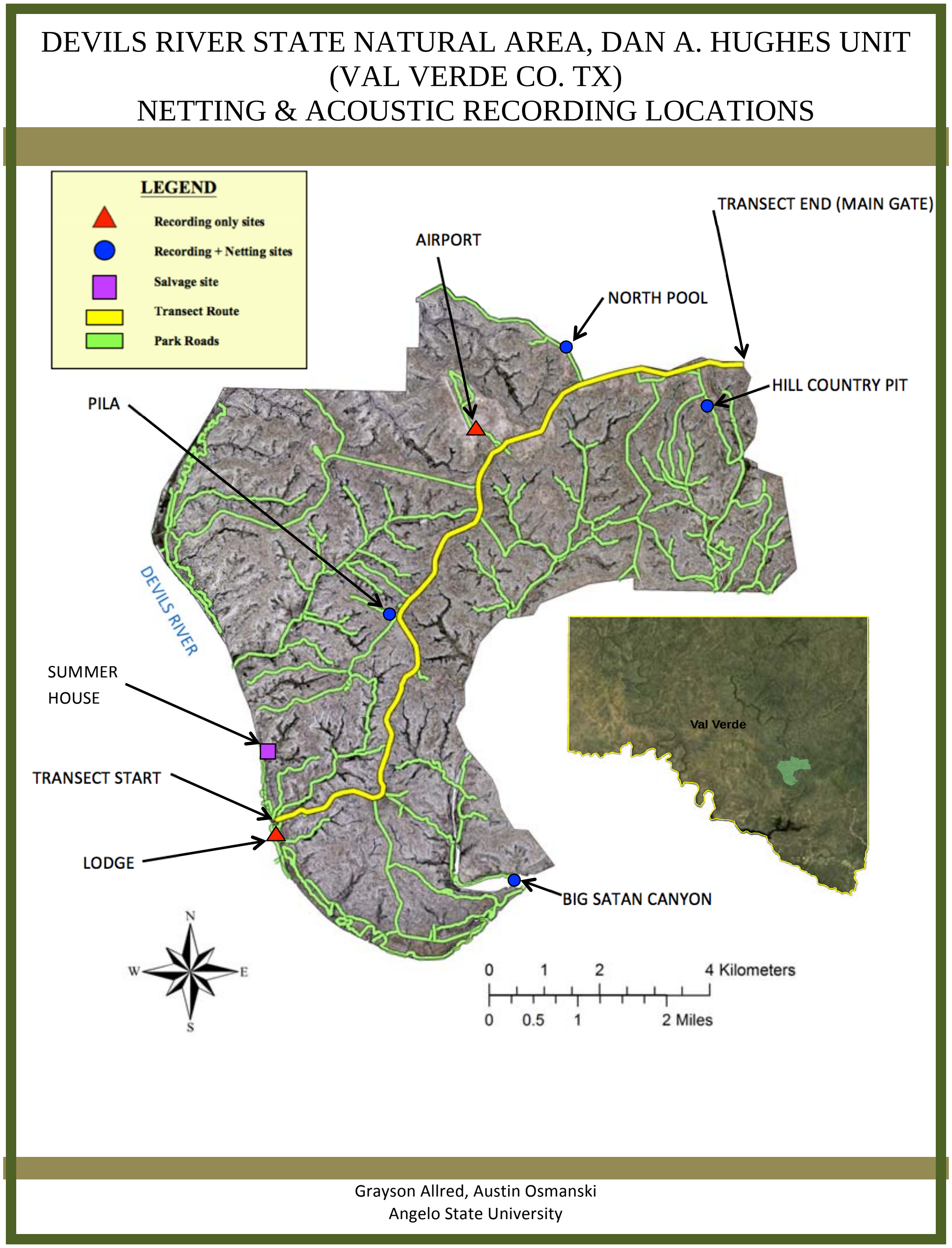

FIG. 2.—Netting and acoustic recording sites sampled for bat surveys from July 2013 to December 2014 at DRNSA-DHU. Route for driving transect for acoustic activity of bat species is shown in yellow.

Mist nets (2.6 meters tall in lengths of 6, 9, or 12 meters wide) were opportunistically deployed over water sources at four netting sites (Pila- 29.70731°N, 100.97815°W; Big Satan Canyon- 29.66388°N, 100.95315°W; North Pool- 29.75151°N, 100.94587°W; Hill Country Pit- 29.74213°N, 100.91912°W). All collection localities were recorded with a global positioning system (GPS) using the WGS-84 coordinate system with readings in latitude and longitude. Upon capture, bats were placed in cloth bags and individually processed. Each bag containing a bat was weighed with a spring scale to the nearest gram. Once emptied, the bags were again weighed by themselves in order to calculate the actual weight of each bat captured. Along with weight, forearm length, ear length, hind foot length, age, reproductive status and condition of each bat was recorded. Morphological measurements were taken using dial calipers and recorded to the nearest tenth of a millimeter. Reproductive status was determined by checking for descended testes in males and for pregnancy in females. Nipples were also checked for signs of lactation in females. Age of the bats was determined by checking for ossification of the metacarpal-phalangeal joint of the third digit of the wing (Ammerman et al. 2012). Individuals were classified as adults if there was no evidence of cartilage in the joint. While handling the bats, all researchers were required to wear leather gloves to help protect against exposure to rabies; to help prevent the spread of white-nose syndrome (WNS), latex gloves were worn over the leather gloves. All used nets and bags were boiled for 20 minutes and/or washed in a 10% bleach solution to help prevent the potential spread of WNS fungus from bat to bat following national guidelines (White-nose Syndrome 2014). Voucher specimens were made for each species captured at a sampling site. Other individuals of the same species captured at the same site were identified in the field and released after measurements were taken. Voucher specimens for nine individuals (see individual Species Accounts) were prepared as museum study skins and skeletons and deposited in the Angelo State Natural History Collections (ASNHC; Appendix 1). Frozen tissue samples for most specimens also were deposited in the Collection of Frozen Tissues, ASNHC. Relative abundance of bat species was assessed using capture data. Species abundance was recorded by calculating the number of bats per net hour (one "net hour" is equal to one net open for one hour). I determined net hours by multiplying the number of nets we had at each site by the number of hours the nets were actually open and active.

Acoustic data collection. — In addition to sampling with mist nets to survey and document species, I also used a handheld acoustic monitoring device, the Echo Meter EM3+ Ultrasonic Recorder (Wildlife Acoustics, Maynard, MA), to detect and record echolocation calls along a 12.9-km driven transect route that ran generally west to east across DRSNA-DHU (Fig. 2). The EM3+ recorded 16-bit full spectrum WAV files allowing for analysis in compatible software. The files were recorded at an audio sample rate of 256 kHz onto a 4GB SDHC card. Each time the EM3+ was triggered and recorded sound files, it also recorded the GPS coordinates, which were embedded and saved with the sound file on the memory card. The transect route transitioned from a lower elevation to a higher elevation, starting at the river and ending by the main entrance gate to the park. Transect data were collected at least once a month during the research period by driving the route at 24 km/hour approximately 30 min after sunset. I started the transect near the entrance to DRSNA-DHU six times (to better accommodate simultaneous research being conducted by fellow graduate students), whereas eighteen times I started it at the river. The EM3+ was held in the back of a truck with the microphone facing upward. Sound files were also recorded at the four netting sites around the survey area and at two other sites (Lodge- 29.67054°N, 100.99875°W; Airstrip-

29.73758°N, 100.96343°W) in which only acoustic sampling was utilized (Fig. 2). The EM3+ was placed in a stationary position on the ground with the microphone facing upwards alongside the nets. At most sites I recorded for 1-2 hours; however, on two nights (28 September 2013 and 17 October 2014) I recorded for 6-7 hours. A GPS antenna was attached to the device and logged the GPS location of recordings and synchronized the clock to the GPS time base with a less than one millisecond error. The GPS used the WGS-84 coordinate system and used WAAS mode for increased accuracy in North America. The uncompressed WAV files recorded onto the 4GB SDHC card were transferred to a computer after each night of recording.

Call identification (acoustic analysis). — I used two approaches to analyze the sound files recorded and identify the echolocation calls to species: 1) subjective manual qualitative analysis of the frequency amplitude, structure, and duration of the calls, and 2) a quantitative analysis software system, Kaleidoscope Pro 3.0.0 (Wildlife Acoustics). Each method identified unknown calls through comparison to a sample of calls of known species identity (i.e., call library). Qualitative identification is the more common approach and identifies call sequences by visual evaluation of each individual call sequence manually (Fenton and Bell 1981; Law et al. 1999; O'Farrell et al. 1999). The quantitative method involves statistical comparison of call parameters from unknown calls with known call sequences (Vaughan et al. 1997).

I manually identified echolocation calls by comparing the structure, duration, and frequency amplitude, of the unknown call files to a few published accounts of previously recorded calls collected from hand-released bats marked with chemiluminescent tags collected from Texas and the mid-west (Fenton and Bell 1981; O'Farrell et al. 1999; Murray et al. 2001). I only attempted identification of echolocation calls containing ≥4 pulses (Johnson et al. 2002). Fragmented and unclear calls were assigned as “NoID.” Sounds such as insect noise, background noise, and potentially bat echolocation that have insufficient data to analyze were labeled as “Noise” by the software and eliminated during initial processing. Identifications were limited to species, as no techniques exist to reliably distinguish male/female or adult/juvenile bat echolocation calls. I used information from Szewczak (2011) and from Adams (2004) as well as assistance from Rogelio Rodriguez (Zotz Ecological Solutions) in order to assist with manual species identifications.

Kaleidoscope Pro is the compatible analysis software for the EM3+ recorder and is an integrated suite of bat data tools designed to help quickly convert files, and sort and categorize bat data by species. During file processing, Kaleidoscope Pro attempts automatic species identification by statistical comparison of call parameters from unknown call files with known call sequences from their built-in classifiers. For this project the “Bats of North America 3.0.0” classifier (which includes 26 species) was utilized to identify calls, using only the Texas region, and further only selecting the species that have been documented from Val Verde County. I used the “+1” setting for more accurate species identification of call files in order to be conservative about the species identifications that resulted from this analysis. Automatic species identification by Kaleidoscope Pro is intended for use in analyzing recordings of single bats in free flight, low clutter environments. On average, more than half of such recordings will result in classifications with at least 80% accuracy (Wildlife Acoustics 2016).

Relative activity based on acoustic data was calculated based on the number of bat “passes” per unit time. These data could not be used to estimate relative abundance of species because individual bats might be detected multiple times. Species diversity and activity at DRSNA-DHU based on acoustic data was summarized and compared. I compared species designations based on manual methods to the software analysis. I also compared species diversity and activity values between recordings collected via the transect route versus the stationary sites.

RESULTS

Traditional sampling (mist netting). — I mist netted at four sites at DRSNA-DHU, accounting for 10 mist net nights and 65.4 mist net hours (number of nets x hours open). I captured a total of 19 bats that included three different species *Antrozous pallidus*, *Myotis velifer*, and *Tadarida brasiliensis* (Table 1; Appendix 2). Most of the captures (10/19) were in Big Satan Canyon (Fig. 3). Here I captured *Myotis velifer* and *Tadarida brasiliensis*. However, this was not the site with the highest netting effort (Fig. 3). North Pool was the site that cost the most effort but was only the second most productive site. Big Satan Canyon was the most productive site and had the least amount of netting effort compared to North Pool. Hill Country Pit, however, had a high amount of effort but zero productivity (Fig. 3). No bats were captured at the Pila or Hill Country Pit sites. One *Myotis velifer* and one *Tadarida brasiliensis* were found dead and salvaged (Appendix 1). Therefore, a total of 3 species were documented based on captures. The most abundant bat was *Tadarida brasiliensis*; however, the bat with the highest occurrence frequency was *Myotis velifer*, which occurred at two of the four sites (Table 1).

TABLE 1.—Summary of bat species captured by mist net in DRSNA-DHU (July 2013 – December 2014).

Species	# Captured	Percent of Capture Frequency	Percent of Occurrence Frequency
Tadarida brasiliensis	9	47.4%	25%
Myotis velifer	8	42.1%	50%
Antrozous pallidus	2	10.5%	25%
Total	19		

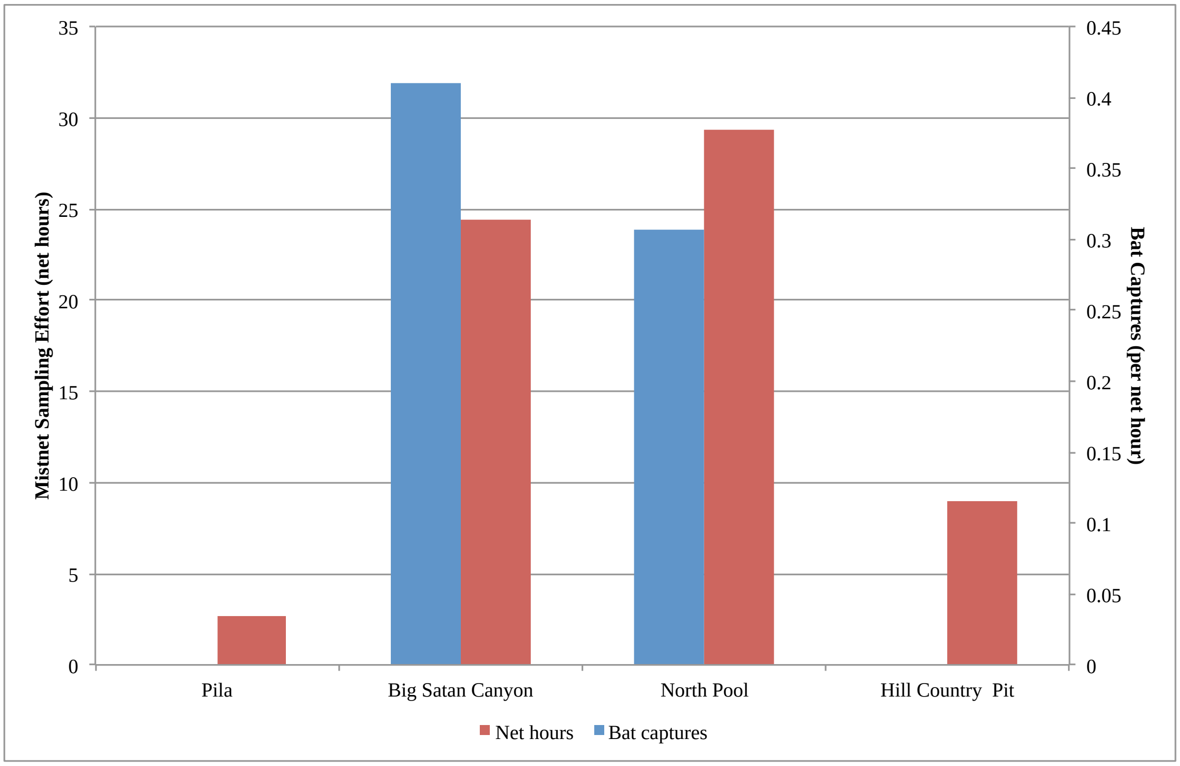

FIG. 3.—Mistnet sampling effort (net hours) and bat captures (per net hour) at four sites sampled at DRSNA-DHU (January 2014 – December 2014).

I also calculated capture rates on different dates (Fig. 4). The date with the highest cost in netting effort was 28 February 2014 but was quite low in productivity. On the other hand, netting effort on 31 May 2014 ranked fifth in terms of effort but had the highest productivity.

There were noticeable differences in the species composition from one site to another. I caught two species at both Big Satan Canyon and North Pool; however, I did not catch the same two species at each site. Each site tended to have one dominant species, *Tadarida brasiliensis* at Big Satan Canyon (capture rate = 0.37 bats/net hour) and *Myotis velifer* at North Pool (capture rate = 0.24 bats/net hour). Only *Myotis velifer* was caught at both sites.

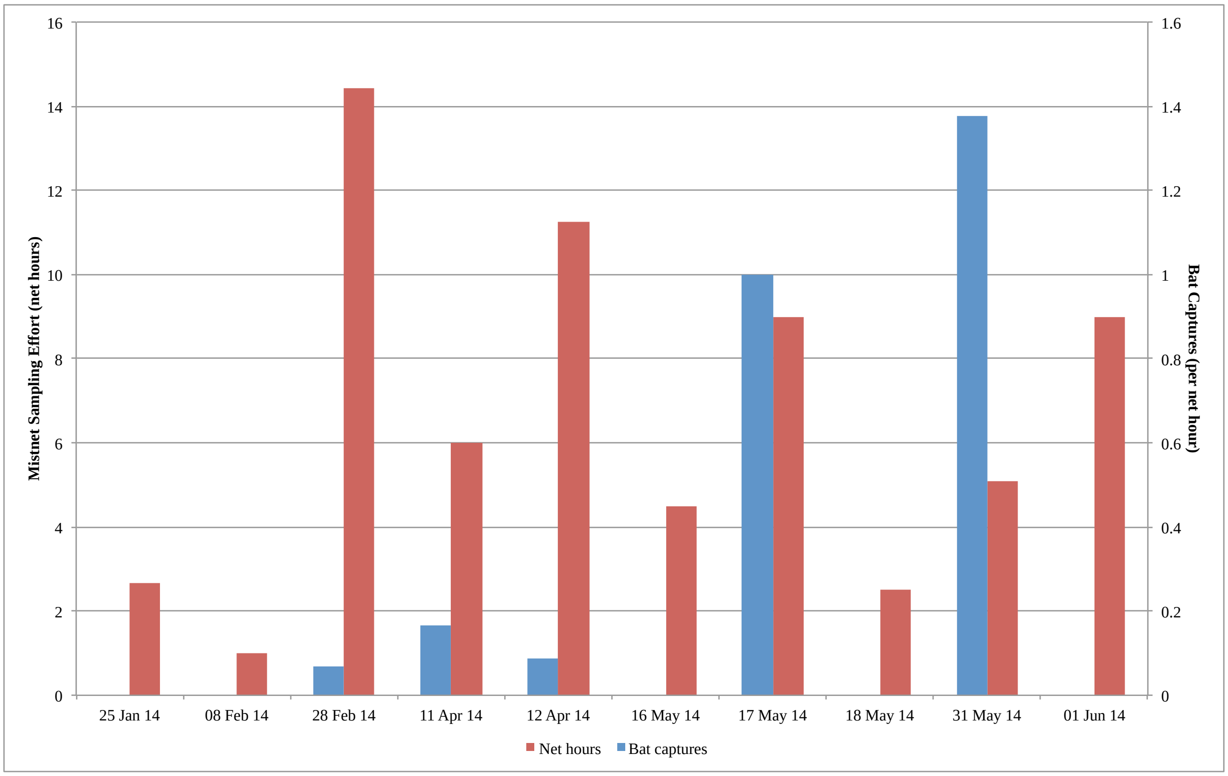

FIG. 4.—Netting effort and bat captures (per net hour) for all dates sampled at DRSNA-DHU (January 2014 – December 2014).

The *M. velifer*, *A. pallidus*, and *T. brasiliensis* captured had weights and measurements well within their published ranges (Ammerman et al. 2012). Most of the 19 bats we caught were adult females, including all nine *T. brasiliensis*. However, three of eight *M. velifer* and one of two *A. pallidus* were males. Only one sub-adult (*M. velifer*) was captured.

Acoustic data collection. — I recorded a total of 10,085 sound files at DRSNA-DHU; 6,965 on the driving transect and 3,120 at stationary sites. From the total number of sound files recorded, 1,606 were recognized as good bat echolocation calls that were used to identify species (Appendix 3), while 8,450 were eliminated as noise files. Generally, more call files with good quality (1,150 compared to 456) were recorded at the stationary sites than from the driving transect. Correspondingly, the stationary sites had fewer number of call files that could not be classified (264) than the driving transect (729; Table 2). There were also more species documented at the stationary sites (13) than from the driving transect (8; Table 2). In total, there were 24 driving transects and 14 nights of stationary recording during the study period (Appendix 3); the number of transects and stationary recording nights varied among seasons (Fig. 5).

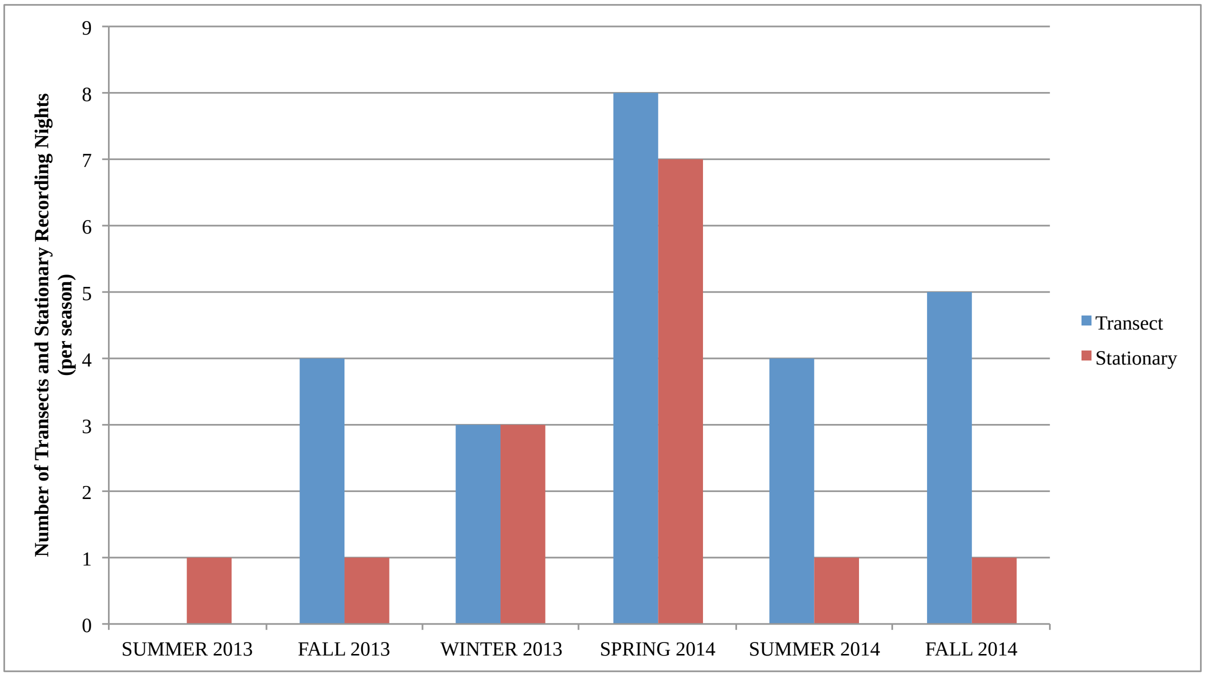

FIG. 5.—Number of transects and stationary recording nights based on season between July 2013 and December 2014.

The number of call files recorded on the driving transect was 6,965, but 93.5% of those were classified as noise files. There were 456 good call files from the transect that were subjected to analysis. The amount of activity (number of good call files per night) on the driving transect was highest in fall 2013 and second highest in fall 2014 compared to other times of the survey period (Fig. 6).

The number of call files recorded at stationary sites was 3,120, but 62.2% of these files were classified as noise. There were 1,150 good call files recorded at stationary sites that were subjected to analysis. The amount of activity (number of good call files per night) at the stationary sites was by far highest in fall 2014 compared to other times of the survey period (Fig. 6).

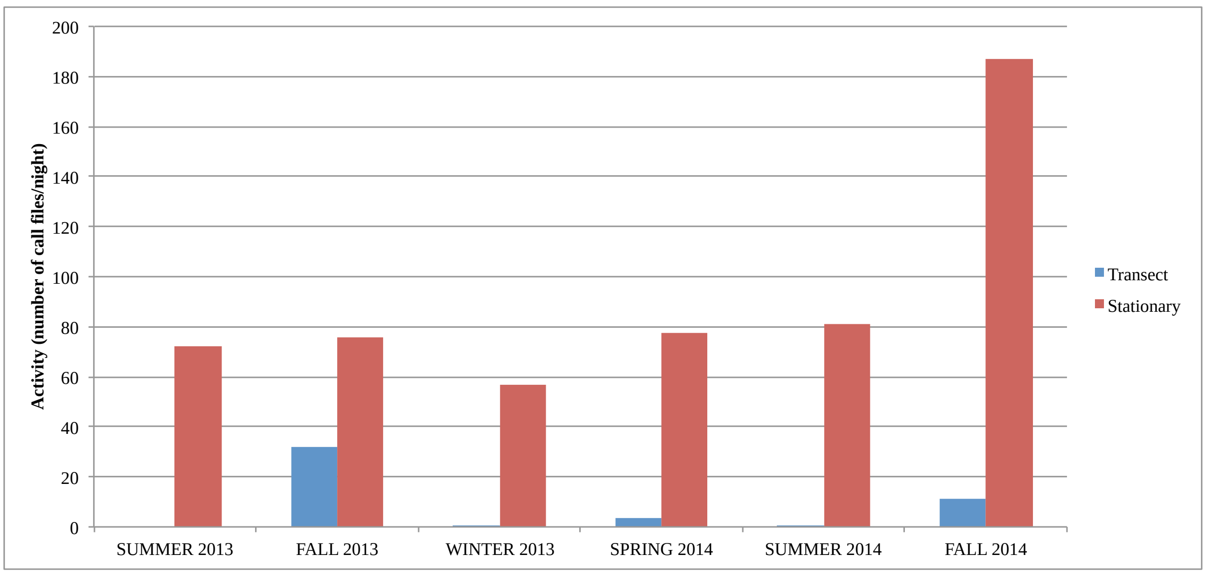

FIG. 6.—Acoustic activity by season for transect surveys and stationary recording sites based on call files recorded at DRSNA-DHU using acoustic data from manual (qualitative) analysis between July 2013 and December 2014. The number of transects and stationary recording nights varied among seasons and have been factored in to the calculation of activity.

Thirteen species were documented at DRSNA-DHU (*Antrozous pallidus*-ANPA, *Corynorhinus townsendii*-COTO, *Lasiurus borealis*-LABO, *Lasiurus cinereus*-LACI, *Lasionycteris noctivagans*-LANO, *Mormoops megalophylla*-MOME, *Myotis velifer*-MYVE, *Myotis yumanensis*-MYYU, *Nycticeius humeralis*-NYHU, *Nyctinomops macrotis*-NYMA, *Parastrellus hesperus*-PAHE, *Perimyotis subflavus*-PESU, *Tadarida brasiliensis*-TABR) based on both methods of call analysis (Table 2); however, results varied between the two analysis methods. Results from the Kaleidoscope software found nine species and manual analysis found thirteen species present at DRSNA-DHU (Table 2).

TABLE 2.—Summary of bat species detected at DRSNA-DHU using acoustic data from stationary sites and driving transects between July 2013 and December 2014.

	STATIONARY SITES			TRANSECTS		
	Kaleidoscope	Manual	Total	Kaleidoscope	Manual	Total
Antrozous pallidus	22	56	78	0	1	1
Corynorhinus townsendii	0	15	15	0	0	0
Lasiurus borealis	471	71	542	83	4	87
Lasiurus cinereus	26	18	44	78	1	79
Lasionycteris noctivagans	46	201	247	12	49	61
Mormoops megalophylla	0	1	1	0	0	0
Myotis velifer	0	218	218	0	0	0
Myotis yumanensis	10	18	28	0	0	0
Nycticeius humeralis	4	63	67	1	6	7
Nyctinomops macrotis	0	2	2	0	0	0
Parastrellus hesperus	2	131	133	2	2	4
Perimyotis subflavus	66	165	231	3	1	4
Tadarida brasiliensis	17	169	186	34	150	184
Not Identified	486	22	508	243	242	485
Total call files	1150	1150	2300	456	456	912

There were differences between manual (qualitative) and software (quantitative) analysis of call files. The manual method identified more *A. pallidus, C. townsendii, L. noctivagans, M. megalophylla, M. velifer, M. yumanensis, N. humeralis, N. macrotis, P. hesperus, P. subflavus,* and *T. brasiliensis* than software analysis (Table 2). Some of these identified species were not in the Kaleidoscope "classifier" (such as *M. velifer*, *M. megalophylla*, and *N. macrotis*) and would not have been identified if I had relied solely on software analysis. Software analysis identified more *L. borealis* and *L. cinereus* than manual analysis (Table 2). Software analysis often classified calls of *T. brasiliensis* as *L. borealis* resulting in a very high number of detections (554) of eastern red bats using the quantitative method. Because the "classifier" did not contain all species expected to occur at DRSNA-DHU (for example, *Myotis velifer*), I will use the outcomes of the qualitative method of analysis in the following results and species accounts.

Using the results from manual analysis, the most prevalent species was the Brazilian free-tailed bat, *Tadarida brasiliensis* with 319 calls recorded (19.9% of identified calls). Species diversity varied on a seasonal basis during the study period with the lowest number of species (5) detected in summer 2014, and the highest number of species (12) detected in spring 2014 (Fig. 7). Species diversity also varied between recordings collected via the transect route and those collected at stationary sites. Seven different species were detected along the transect route while thirteen species were detected at the stationary sites. Species diversity varied between recording locations during the study period with the lowest number of species (0) detected at the Pila, and the highest number of species (11) detected at both the Big Satan Canyon and North Pool locations (Fig. 8). The most prevalent species at: Big Satan Canyon was *L. noctivagans;* at the Lodge was *T. brasiliensis*; at the North Pool was *P. subflavus*; at the Hill Country Pit was *M. velifer;* and at the Airstrip was *T. brasiliensis* (Table 3). No species were detected at the Pila.

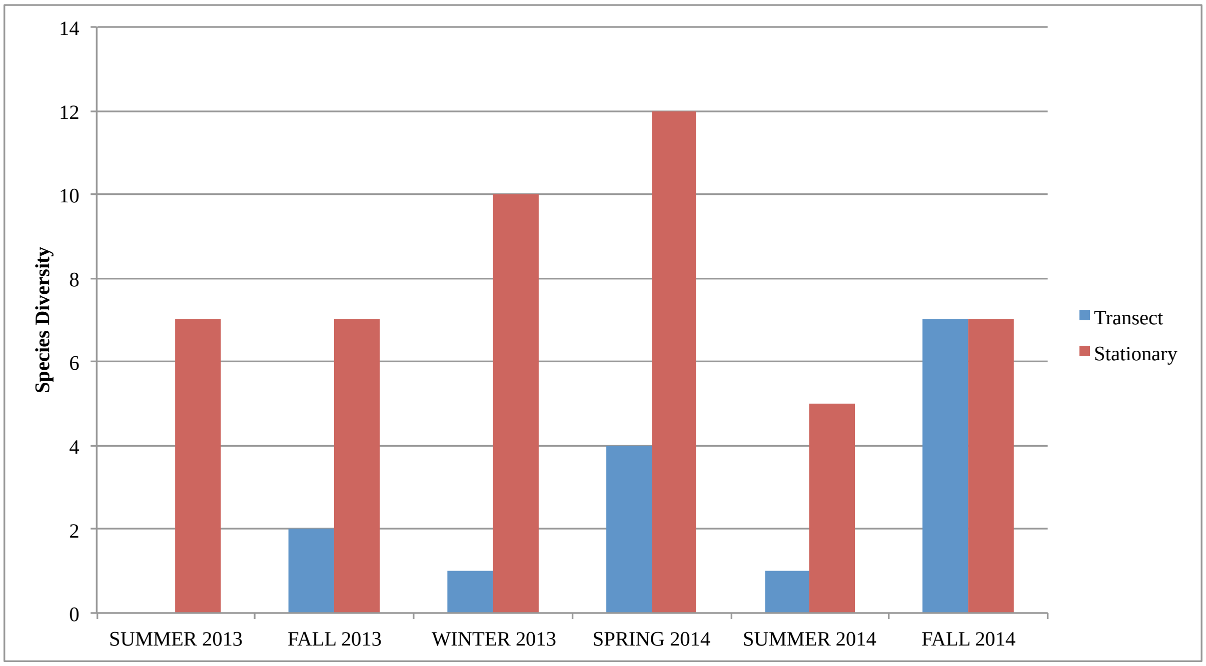

FIG. 7.—Comparison of species diversity by number of bat species among seasons based on transect surveys and stationary recording sites at DRSNA-DHU using acoustic data from manual (qualitative) analysis between July 2013 and December 2014.

Individual bat species activity (number of good call files per transect/night) also varied among seasons. Using the results from manual (qualitative) analysis for the transect surveys, no species were detected in all six seasons of the survey period (Table 4). The species detected most frequently on the transect was *Tadarida brasiliensis*, detected in four out of six seasons of the survey period, followed closely by *Lasionycteris noctivagans* detected in three out of six seasons of the survey period.

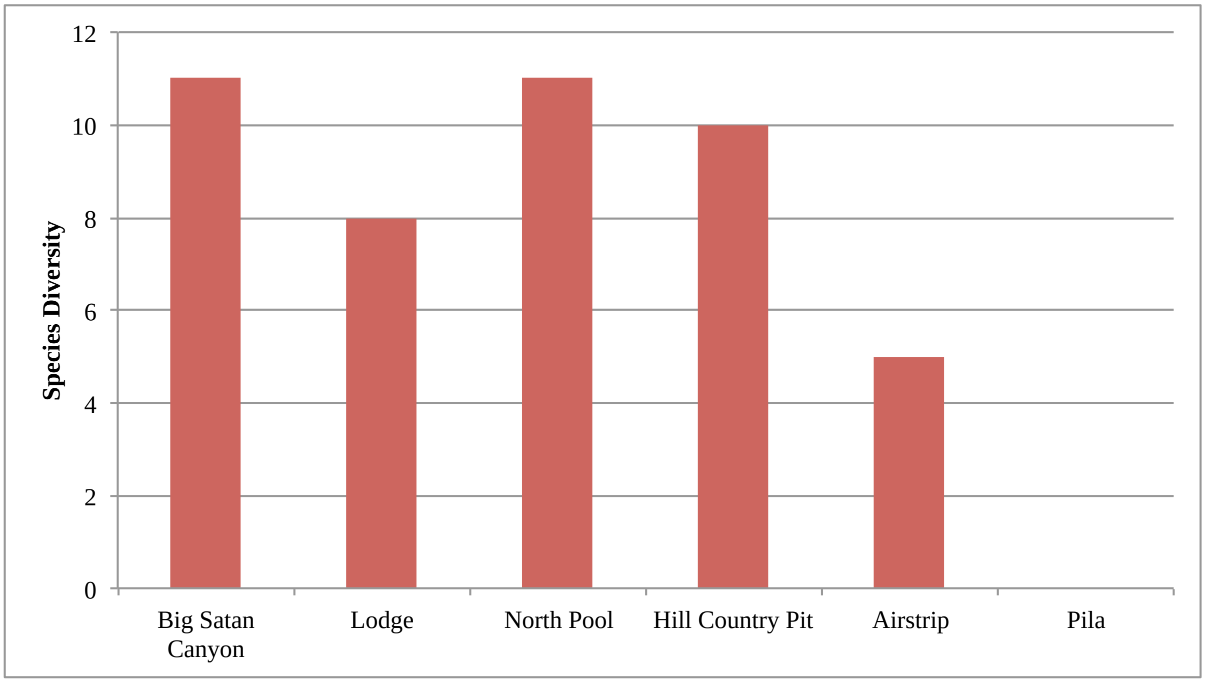

FIG. 8.—Comparison of species diversity by number of bat species among stationary recording locations at DRSNA-DHU using acoustic data from manual (qualitative) analysis between July 2013 and December 2014.

Taking effort into account, silver-haired bat activity was greatest in fall 2014, followed by fall 2013, and lowest (excluding zero activity) during the spring of 2014. Brazilian free-tailed bat activity was by far highest in fall 2013, followed by lower activity in spring and fall 2014. Brazilian free-tailed activity was lowest (excluding zero activity) in winter 2013 (Table 5).

Using the results from manual (qualitative) analysis for the stationary recording locations, three species were detected in all seasons: *Antrozous pallidus*, *Lasiurus borealis*, and *Tadarida brasiliensis* (Table 4).

TABLE 3.—Summary of bat species prevalence based on call files recorded at stationary sites at DRSNA-DHU using acoustic data from manual (qualitative) analysis between July 2013 and December 2014.

	Big Satan Canyon	Lodge	North Pool	Hill Country Pit	Airstrip	Pila
ANPA	37	9	3	5	2	0
COTO	12	0	3	0	0	0
LABO	5	13	34	16	3	0
LACI	15	0	1	0	2	0
LANO	106	10	19	31	35	0
MOME	1	0	0	0	0	0
MYVE	4	11	87	116	0	0
MYYU	0	0	12	6	0	0
NYHU	1	8	50	4	0	0
NYMA	0	0	0	2	0	0
PAHE	11	18	69	33	0	0
PESU	17	34	106	8	0	0
TABR	59	45	14	12	39	0
NOID	1	14	5	0	2	0
Total	269	162	403	233	83	0

Taking effort into account, Pallid bat activity was greatest in winter 2013, closely followed by summer 2013, and lowest during the summer of 2014. Eastern red bat activity was greatest in fall 2014, next highest in fall 2013, and lowest during the summer of both years. Brazilian free-tailed activity was highest in fall 2013, followed closely by high activity in summer 2014. Brazilian free-tailed activity was lowest in fall 2014 (Table 5).

TABLE 4.—Summary of total number of identified call files for individual bat species by season for transect surveys and stationary recording sites based on call files recorded at DRSNA-DHU using acoustic data from manual (qualitative) analysis between July 2013 and December 2014.

	Summer 2013		Fall 2013		Winter 2013		Spring 2014		Summer 2014		Fall 2014	
	Stat	Tran	Stat	Tran	Stat	Tran	Stat	Tran	Stat	Tran	Stat	Tran
ANPA	6	0	3	0	19	0	21	0	2	1	5	0
COTO	0	0	0	0	2	0	13	0	0	0	0	0
LABO	3	0	10	0	5	0	35	1	3	0	15	3
LACI	0	0	0	0	13	0	3	0	2	0	0	1
LANO	0	0	10	10	72	0	55	4	35	0	29	35
MOME	0	0	0	0	1	0	0	0	0	0	0	0
MYVE	8	0	3	0	4	0	98	0	0	0	105	0
MYYU	0	0	0	0	0	0	12	0	0	0	6	0
NYHU	3	0	5	0	0	0	55	3	0	0	0	3
NYMA	0	0	0	0	0	0	2	0	0	0	0	0
PAHE	13	0	5	0	11	0	76	0	0	0	26	2
PESU	34	0	0	0	16	0	115	0	0	0	0	1
TABR	5	0	40	118	27	1	57	21	39	0	1	10
NOID	1	0	13	31	1	16	5	18	2	154	0	23
Total	73	0	89	159	171	17	547	47	83	155	187	78

TABLE 5.—Individual bat species activity (number of good call files per night) by season for transect surveys and stationary recording sites based on call files recorded at DRSNA-DHU using acoustic data from manual (qualitative) analysis between July 2013 and December 2014. The number of transects and stationary recording nights (amount of effort) varied among seasons (refer to Fig. 5) and have been factored in to the calculation of activity.

	Summer 2013		Fall 2013		Winter 2013		Spring 2014		Summer 2014		Fall 2014	
	Stat	Tran	Stat	Tran	Stat	Tran	Stat	Tran	Stat	Tran	Stat	Tran
ANPA	6	0	3	0	6.33	0	3	0	2	0.25	5	0
COTO	0	0	0	0	0.67	0	1.86	0	0	0	0	0
LABO	3	0	10	0	1.67	0	5	0.13	3	0	15	0.6
LACI	0	0	0	0	4.33	0	0.43	0	2	0	0	0.2
LANO	0	0	10	2.5	24	0	7.86	0.5	35	0	29	7
MOME	0	0	0	0	0.33	0	0	0	0	0	0	0
MYVE	8	0	3	0	1.33	0	14	0	0	0	105	0
MYYU	0	0	0	0	0	0	1.71	0	0	0	6	0
NYHU	3	0	5	0	0	0	7.86	0.38	0	0	0	0.6
NYMA	0	0	0	0	0	0	0.29	0	0	0	0	0
PAHE	13	0	5	0	3.67	0	10.9	0	0	0	26	0.4
PESU	34	0	0	0	5.33	0	16.4	0	0	0	0	0.2
TABR	5	0	40	29.5	9	0.33	8.14	2.63	39	0	1	2

SPECIES ACCOUNTS

The following accounts include three families and 13 species of bats that were documented at Devils River State Natural Area, Dan A. Hughes Unit. The sequence of species accounts conforms to the phylogenetic order presented in Ammerman et al. (2012). Scientific and common names also follow Ammerman et al. (2012).

Order Chiroptera

Family Mormoopidae

There is only one species of this family that occurs in the United States, the ghost-faced bat, *Mormoops megalophylla*, which has been recorded in Texas and Arizona (Ammerman et al. 2012).

Mormoops megalophylla Peters, 1864 (ghost-faced bat): This species produces a long-duration call (Fig. 9) in which the initial element of its constant frequency ends in a short and swift controlled component used for aerial pursuit of large-bodied moths. The ghost-faced bat echolocation call begins around 55 kHz and curves gradually to about 45 kHz (Adams 2004).

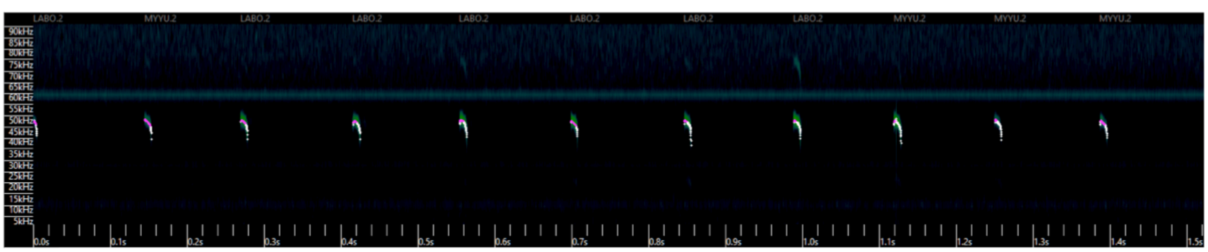

FIG. 9.—Example of echolocation call of *M. megalophylla* as seen in Kaleidoscope software (28 February 2014; 29.66387°N, 100.95322°W).

The ghost-faced bat is found in Texas in the Chihuahuan Desert region (Trans-Pecos), southern edge of the Edwards Plateau, and Gulf Coastal Plains. This species is normally encountered in lowland areas (below 3,000 m in elevation; Rezsutek and Cameron 1993), specifically desert scrub and riverine habitats. The Ghost-faced bat commonly can be found in caves along the extreme southern edge of the Edwards Plateau during winter (November 1 to March 15). This seems to be the northern distributional limit for this species in the United States. Nonetheless, its occurrence at specific localities is greatly variable and erratic (Ammerman et al. 2012).

I encountered the Ghost-faced bat only once at DRSNA-DHU during the course of this survey. It was detected acoustically at Big Satan Canyon in winter 2014. Because the echolocation call is distinctive it is unlikely to be confused with other species. I did not capture this species by mist net.

Family Vespertilionidae

The Vespertilionidae are found in almost every possible habitat from tropical forests to desert and temperate regions, and most of the species in Texas belong to this family. Thirty-three species of vespertilionid bats range across the United States; of these, 25 are known from Texas. Several vespertilionid bats are highly migratory and cross great distances between their summer and winter ranges. Others, though, do not migrate and instead hibernate in their summer ranges (Ammerman et al. 2012).

Myotis velifer (J.A. Allen, 1890) (cave myotis): Based on comparison with known reference calls of *M. velifer*, the echolocation call for the cave myotis (Fig. 10) is very similar to that of the yuma myotis, which has a moderate-length, steeply curved frequency-modulated echolocation call. The starting frequency varies broadly, usually between 55 and 80 kHz, and bends slightly down to about 40-50 kHz.

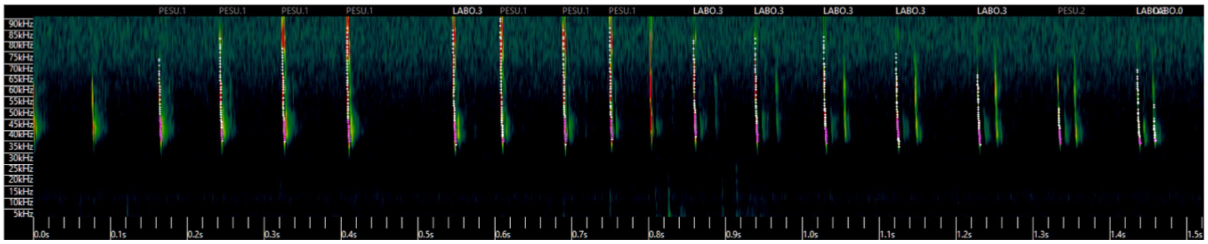

FIG. 10.—Example of echolocation call of *M. velifer* as seen in Kaleidoscope software (17 October 2014; 29.74212°N, 100.91912°W).

M. velifer can be found in Texas throughout the year, though it displays a diverse seasonal distribution in the western two-thirds of the state. This species occupies every ecological region in Texas except for the South Central Plains from late spring to early fall (March 16 to October 31). During late fall and winter (November 1 to March 15), however, cave myotis seem to be limited to the central and north-central parts of the state. This species has been captured once during the winter in the Trans-Pecos (Presidio County in February; Yancey and Jones 1996), and no records exist from the Rio Grande Valley (Ammerman et al. 2012).

During this survey, the Cave myotis was captured at two sites, the North Pool (7 individuals) and Big Satan Canyon (1 individual) (Fig. 2). There was also one male *M. velifer* that was found dead near the Big Satan Canyon netting site on 20 July 2013 and prepared as a voucher specimen. I did not detect *M. velifer* acoustically on the driving transects but it was the most common call file recorded (218 detections) at stationary locations. I recorded this species at the following locations: Big Satan Canyon, Lodge, North Pool, and Hill Country Pit (Table 3). The Cave myotis was detected in all seasons of the survey period, except summer 2014. Almost half of the detections were either in spring 2014 (98/218, 44.9%) or fall 2014 (105/218, 48.2%).

Specimens examined (5): North Pool, 1 male collected 11 April 2014 (ASNHC 17607), 1 male collected 12 April 2014 (ASNHC 17606), 1 male collected 31 May 2014 (ASNHC 17608); Big Satan Canyon, 1 male salvaged 20 July 2013 (ASNHC 17686), 1 female with pup collected 17 May 2014 (ASNHC 17604).

Myotis yumanensis (H. Allen, 1866) (yuma myotis): The yuma myotis hunts insects almost exclusively over water. To do this, they use moderate-length, steeply curved frequency-modulated echolocation calls (Fig. 11). The starting frequency varies broadly, between 59 and 72 kHz, and curves abruptly down to 45-50 kHz (Adams 2004).

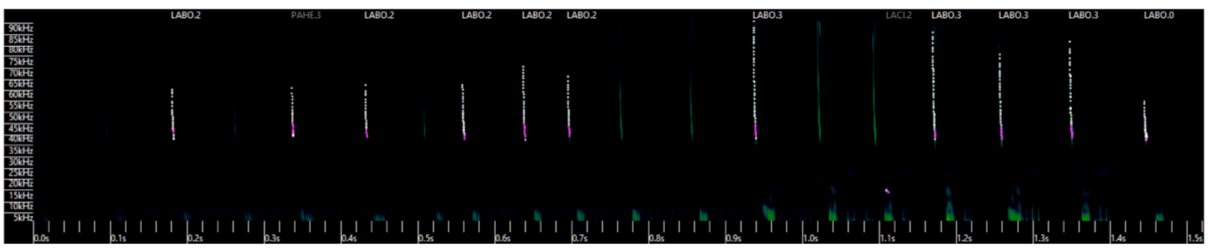

FIG. 11.—Example of echolocation call of *M. yumanensis* as seen in Kaleidoscope software (31 May 2014; 29.75151°N, 100.94587°W).

M. yumanensis can be found in the southern Chihuahuan Desert ecoregion and the area just east of the Pecos River in Val Verde County during summer months. There is one lone record of this species from Starr County in the Southern Texas Plains region. The yuma myotis prefers to forage in a lowland habitat close to open water, which is where it can usually be found. The majority of specimens collected in Texas have been collected in lowland habitats near the Rio Grande; however, numerous specimens also have been acquired from the Chisos Mountains. It is a common belief that *M. yumanensis* remains in the Trans-Pecos region during the winter. Capture records from January through November suggest this is true. Still, little is known about their winter habits (Ammerman et al. 2012).

I did not capture the yuma myotis during my survey period, nor was it acoustically detected on the driving transect. However, I did detect this species acoustically 18 times at two stationary locations (12 at North Pool and 6 at Hill Country Pit). The majority of the acoustic detections of *M. yumanensis* (12/18, 66.7%) were in spring 2014. The rest of the acoustic detections (6/18; 33.3%) were in fall 2014.

Lasiurus borealis (Muller, 1776) (eastern red bat): The echolocation calls of eastern red bats (Fig. 12) are comparable to western red bats, except that in some parts of the sequence, the ending frequency increases so suddenly, compared to that of the middle portion of the call, that a cuplike appearance is obvious in spectrographs. The vocalization begins as a sharply curved, frequency-modulated call between 40 and 60 kHz. It then drops as low as 27-40 kHz, and in some cases rebounds as much as 3-4 kHz above the lowest frequency when ending. Eastern red bats use this echolocation call pattern during gradual, flickering, intermittent flight that they begin at high altitude, and then drop to treetop level in aerial pursuit of mainly moths (Adams 2004).

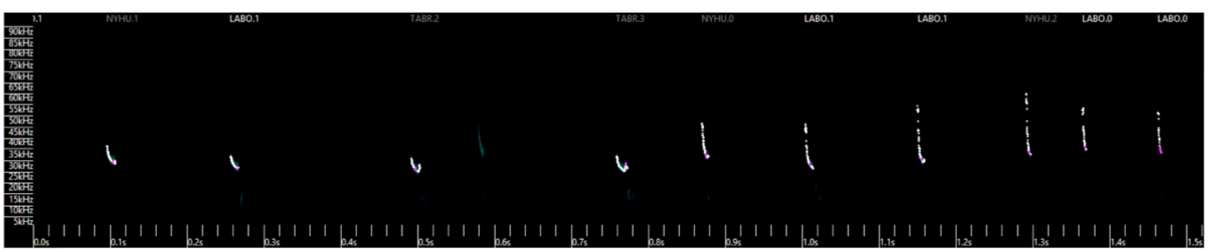

FIG. 12.—Example of echolocation call of *L. borealis* as seen in Kaleidoscope software (31 May 2014; 29.75151°N, 100.94587°W).

Eastern red bats are a forest-dwelling species that roost in trees. They can be found all over Texas and it is one of the most common bat species of the eastern part of the state (Schmidly 2004). There are not many records of *L. borealis* from the Chihuahuan Desert region (Easterla 1975). Here, the species seems to be restricted principally to mountainous areas.

Lasiurus borealis is an extremely migratory species that travels vast distances during its seasonal journeys. There is even documentation of this species being found 105 km out to sea during fall migration (Carter 1950). Though it is found in eastern Texas throughout the year, there are fewer collecting records in winter months. During winter months it does occur in the southeastern United States and northeastern Mexico, but numbers mainly come from the coastal Atlantic and Gulf of Mexico regions (Ammerman et al. 2012). It is believed that eastern red bats only migrate to and inhabit the Trans-Pecos region of Texas during the summer.

I did not capture the eastern red bat during my survey period. This species was acoustically detected 71 times at five of the six stationary locations (5 at Big Satan Canyon, 13 at the Lodge, 34 at North Pool, 16 at Hill Country Pit, and 3 at the Airstrip). Almost half of the total detections at stationary sites (34/71; 47.9%) were from the North Pool in May 2014. Almost all of the total detections (85.3%) were during spring 2014 (36/75; 48%), fall 2013 (10/75; 13.3%), and fall 2014 (18/75; 24%). However, there were 5 detections of the species in winter 2013 at Big Satan Canyon. Eastern red bats also were detected on the driving transect a total of four times: three times in fall 2014 and once in spring 2014.

Lasiurus cinereus (Palisot de Beauvois, 1796) (hoary bat): Hoary bats have mostly frequency modulated (FM) echolocation calls that are long in duration. They also have scattered constant frequency (CF) calls that are useful in long-distance aerial pursuit in open habitats, where they mainly pursue moths. In some instances, a single vocalization will include both FM and CF components. The hoary bat echolocation call varies in its initial frequency, sometimes beginning in the 25 kHz range and ending at about 18 kHz, and at other times beginning as high as 41 kHz and ending at 20-24 kHz (Fig. 13; Adams 2004). The echolocation call of hoary bats can be differentiated from that of other lasiurines because the hoary bat echolocates at a lower frequency than most other bats of this group (Tuttle 1995).

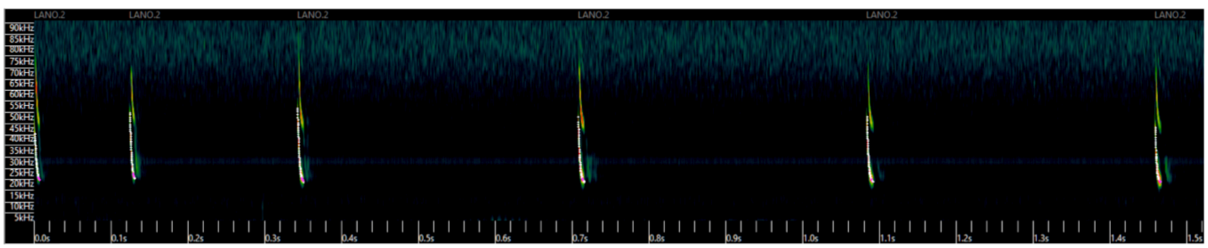

FIG. 13.—Example of echolocation call of *L. cinereus* as seen in Kaleidoscope software (08 Feb 2014; 29.66388°N, 100.95315°W).

Hoary bats are a forest-dwelling species that has been recorded throughout the North American continent and from dispersed areas in Texas. This species has been documented from every major ecological region in the state (Ammerman et al. 2012). Common belief is that this species favors forested areas. However, *L. cinereus* has been captured in lowland desert areas and along the Rio Grande in southern Texas and northern Mexico. There is not much known about the winter habits of this species (Cryan 2003; Ammerman et al. 2012) and the general pattern for hoary bats in Texas is one of a spring-fall migrant. However, according to Ammerman et al. (2012), this species may also overwinter in the state.

I did not capture the hoary bat during my survey period, but this species was acoustically detected 18 times at 3 stationary sites (15 at Big Satan Canyon, 1 at North Pool, and 2 at Airstrip). I also detected *L. cinereus* on the driving transect once. This species was detected in all seasons but the majority of the acoustic detections (13/19; 68.4%) were in winter 2013.

Lasionycteris noctivagans Le Conte, 1831 (silver-haired bat): Silver-haired bats emit echolocation calls (Fig. 14) in which the curves begin as fragmented, sharply modulated calls at about 45-55 kHz but develop in a more constant frequency vocalization toward the terminal and lengthier portion of the call that drops from 30 to 26 kHz (Adams 2004). Calls of this species can sometimes be confused with those of *Eptesicus fuscus*; however, the call of the big brown bat does not quite have the dramatic bend like that of the silver-haired bat (R. Rodriguez, pers.comm). *L. noctivagans* can also produce a flat call similar to that of *Tadarida brasiliensis* but generally at a higher frequency (R. Rodriguez, pers.comm).

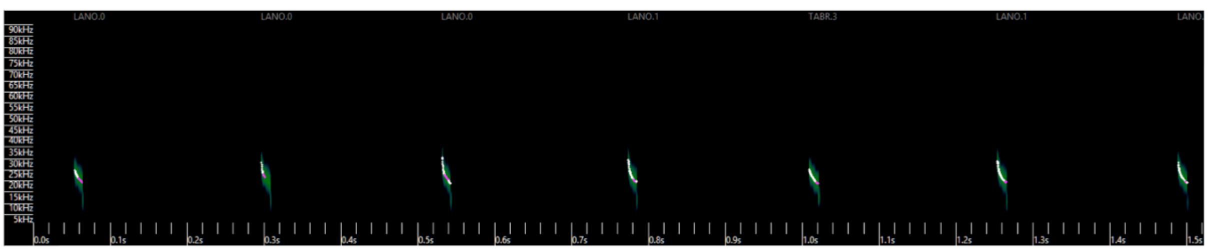

FIG. 14.—Example of echolocation call of *L. noctivagans* as seen in Kaleidoscope software (28 Feb 2014; 29.66387°N, 100.95322°W).

In North America, *L. noctivagans* has a wide but irregular distribution. According to Ammerman et al. (2012), the species has been documented from areas spread throughout Texas and seems to be a fall-spring migrant in the state. The silver-haired bat is found in eight physiographic regions— only absent from the East Central Texas Plains, Blackland Prairies, Cross Timbers, and Southern Texas Plains regions of Texas. However, this bat could be found throughout the state (Ammerman 2005; Ammerman et al. 2012). Also according to Ammerman et al. (2012), there have been few midsummer records of this species in Texas

I did not capture the silver-haired bat during my survey period but this species had the second highest number of detections at stationary sites and on the driving transect. Silver-haired bats were acoustically detected 201 times (106 at Big Satan Canyon, 10 at the Lodge, 19 at North Pool, 31 at Hill Country Pit, and 35 at Airstrip) at stationary sites. Most of these detections at stationary sites were in winter 2013 (72/201; 35.8%) and spring 2014 (55/201; 27.4%), although this species was detected in all seasons of the survey period, excluding summer 2013. This species was detected 49 times on the driving transect; 10 times in fall 2013, 4 times in spring 2014, and 35 times in fall 2014.

Parastrellus hesperus (H. Allen, 1864) (American parastrelle): The echolocation call of the American parastrelle has a hockey stick or fishhook shape but without the end dramatically curving upwards (R. Rodriguez, pers.comm; Fig. 15). The call is very similar to that of *P. subflavus* but could have a higher frequency and a shorter duration; however, they do overlap (R. Rodriguez, pers.comm). The echolocation call of *P. hesperus* is a strongly inflected, almost vertical frequency-modulated call that begins at a frequency in the 50-71 kHz range and ends in the 44-47 kHz range (Szewczak 2011).

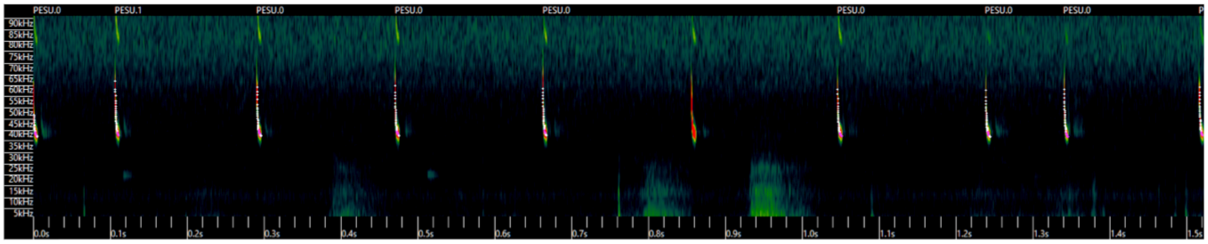

FIG. 15.—Example of echolocation call of *P. hesperus* as seen in Kaleidoscope software (31 May 2014; 29.75151°N, 100.94587°W).

This species can be found in highest concentrations in the mountain ranges and rocky canyon country of the Chihuahuan Desert region. Though the majority of reports of this species come from the Chihuahuan Desert region, the American parastrelle has also been reported from a variety of areas including the: Southern Texas Plains, Central Texas Plains, Southwestern Tablelands, High Plains, the northern and western edge of the Edwards Plateau, and the Arizona/New Mexico Mountains regions (Ammerman et al. 2012).

In Texas, one is most likely to encounter this species in the rocky canyon drainages in desert scrub habitat. American parastrelle activity is known to be intermittent during the winter in Texas (Ammerman et al. 2012). As a result, there are only a few winter records (December, January, and February) that have been reported. There is also no evidence that the species migrates. According to Genoways et al. (1979), in Texas *P. hesperus* do not enter a deep torpor and are capable of waking up and becoming active during warm spells in winter.

The American parastrelle was not captured during my survey period but it was collected from DRSNA-DHU in spring 2015 after my survey period (Dowler et al. 2016). I did acoustically detect this species on the driving transect twice and it was the fifth most common call file recorded (131 detections) at stationary locations. *Parastrellus hesperus* was recorded at Big Satan Canyon (11 detections), Lodge (18 detections), North Pool (69 detections), and Hill Country Pit (33 detections). This species was detected in all seasons at the stationary sites but was more commonly recorded (76/131; 58%) in spring 2014. The two times it was acoustically detected via transect were both during fall 2014.

Perimyotis subflavus (F. Cuvier, 1832) (American perimyotis): American perimyotis bats have an echolocation call that is shaped like a hockey stick or fishhook with an end that does not dramatically curve upwards (Fig. 16). The call of this species is very similar with vocalizations of *P. hesperus*, except that the American perimyotis may have a lower frequency/longer duration call. The calls of the two species do overlap (R. Rodriguez, pers.comm). The call of this species is also a strongly inflected, almost vertical frequency-modulated call that changes to a low slope below about 40-50 kHz. The American parastrelle echolocation call typically begins at a frequency in the 45-68 kHz range and ends in the 40-46 kHz range (Adams 2004).

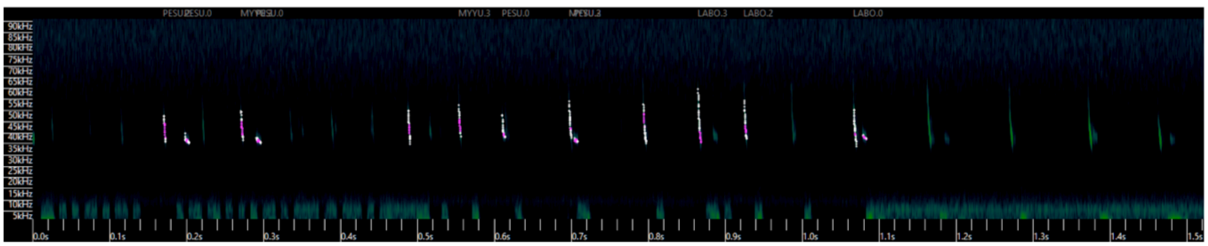

FIG. 16.—Example of echolocation call of *P. subflavus* as seen in Kaleidoscope software (31 May 2014; 29.75151°N, 100.94587°W).

This species can be found in 10 physiographic regions of Texas (Ammerman 2005). However, one is most likely to encounter American perimyotis in the eastern portion of the state (Ammerman et al. 2012). In this region, it is frequently documented along bottomland streams and forest flyways. According to Sandel et al. (2001), American perimyotis are known to hibernate in caves and box culverts within its summer range and are found in Texas throughout the year.

I did not capture the American perimyotis during my survey period. However, I did detect this species acoustically once on the driving transect and 165 times at 4 stationary locations. Most of the calls I recorded of this species at the stationary locations (106/165; 64.2%) were detected at North Pool. It was also detected at the Big Satan Canyon (17), Lodge (34), and Hill Country Pit (8) locations. I detected *Perimyotis subflavus* in all seasons of the year. At stationary sites it was most abundant during spring 2014 (115/165; 69.7%), but was also detected in winter 2013 (16/165; 9.6%) and summer 2013 (34/165; 20.6%). The one time it was detected on the driving transect was during fall 2014.

Nycticeius humeralis (Rafinesque, 1818) (evening bat): Based on comparisons with known reference calls of this species, the echolocation calls of the evening bat are similar to that of a myotis bat but also somewhat like that of *Lasiurus borealis* (Fig. 17; R. Rodriguez, pers.comm). They tend to have a moderate-length, sharply curved frequency-modulated echolocation call.

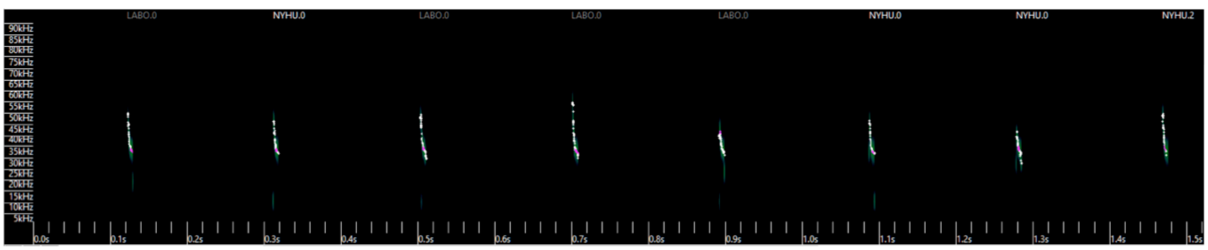

FIG. 17.—Example of echolocation call of *N. humeralis* as seen in Kaleidoscope software (31 May 2014; 29.75151°N, 100.94587°W).

Evenings bats are found in an area that includes most of the eastern part of the United States, stretches west all the way to Nebraska, then expands to the south into northeastern Mexico. The evening bat is primarily found in the eastern part of Texas, but scattered accounts from west Texas may imply a range extension in the state, similar to what has apparently happened in Nebraska and Kansas (Dowler et al. 1999; Geluso et al. 2008; Phelps et al. 2008). In the eastern half of Texas, *N. humeralis* can be found in 7 different ecological regions: the South Central Plains (Pineywoods), East Central Texas Plains, Cross Timbers, Blackland Prairies, Edwards Plateau, Southern Texas Plains, and Gulf Coastal Plains.

According to Schmidly (2004), this species usually inhabits forested areas and is frequently encountered along water sources year-round.

It is not really known how far north or south evening bats migrate, however in the United States, this species is migratory and tends to favor southern regions during winter months (Boyles et al. 2003; Humphrey and Cope 1968; Saugey et al. 1988). *N. humeralis* have been documented from late March through September in Texas (Ammerman et al. 2012). There have been relatively few evening bats collected in winter and no winter roosts in Texas have been documented; as a result, not much is known about the winter behaviors of this species (Ammerman et al. 2012).

I did not capture the evening bat during my survey period; however, I did detect this species acoustically 6 times on the driving transect and 63 times at 4 stationary locations. Most of the calls of *N. humeralis* recorded at stationary sites (50/63; 79.4%) were detected at the North Pool location. I also detected this species at the Big Satan Canyon (1), Lodge (8), and Hill Country Pit (4) locations. There were no detections of this species in winter 2013 or summer 2014; however, they were present in all of the other seasons of the survey period. Out of the total acoustic detections of this species, the majority occurred in spring 2014 (58/69; 84.1%), followed by fall 2013 (5/69; 7.25%), then summer 2013 and fall 2014 (3/69; 4.3%).

Corynorhinus townsendii (Cooper, 1837) (Townsend's big-eared bat): Townsend's big-eared bat emits a short-duration echolocation call that curves sharply then breaks (Fig. 18). It is a frequency-modulated call that begins at about 60 kHz and ends at about 20-30 kHz. Townsend's big-eared bats use these calls to forage for small-bodied moths and other insects along the edges of forests, using two strategies: gleaning and aerial-pursuit (Adams 2004).

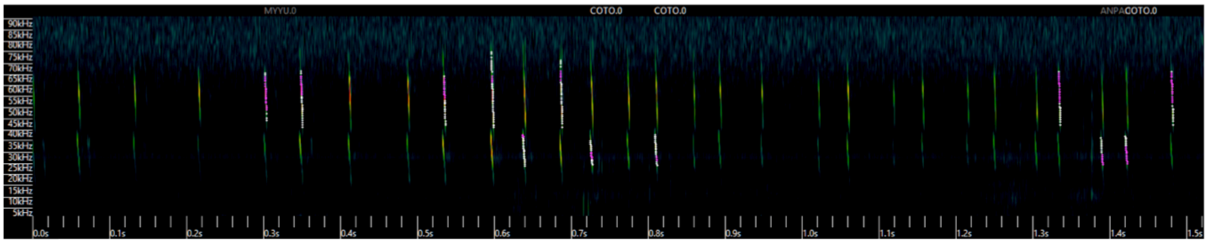

FIG. 18.—Example of echolocation call of *C. townsendii* as seen in Kaleidoscope software (17 May 2014; 29.66388°N, 100.95315°W).

The range for *C. townsendii* encompasses the western half of the United States, with isolated populaces occurring in the Ozarks and the Appalachians. This species can be found throughout 6 ecological regions of Texas: the Central Great Plains, Southwestern Tablelands, High Plains, Edwards Plateau, Chihuahuan Desert, and Arizona/New Mexico Mountains. Vegetative associations do not limit its distribution, and there have been specimens collected in various habitats that range from desert scrub to pinyon-juniper woodlands. The existence of rocky, fragmented terrain is consistent with the capture of these bats, though (Ammerman et al. 2012). According to Schmidly (1977), this is possibly the most representative bat of caves and mine tunnels in the Trans-Pecos region of Texas.

Townsend’s big-eared bat can be found in Texas throughout the year, and is known to hibernate in caves throughout its range. Accounts of this species during winter exist from the High Plains, Southwestern Tablelands, and Central Great Plains regions of Texas, and it is one of limited species of Trans-Pecos bats that can be encountered on a regular basis during this season (Ammerman et al. 2012).

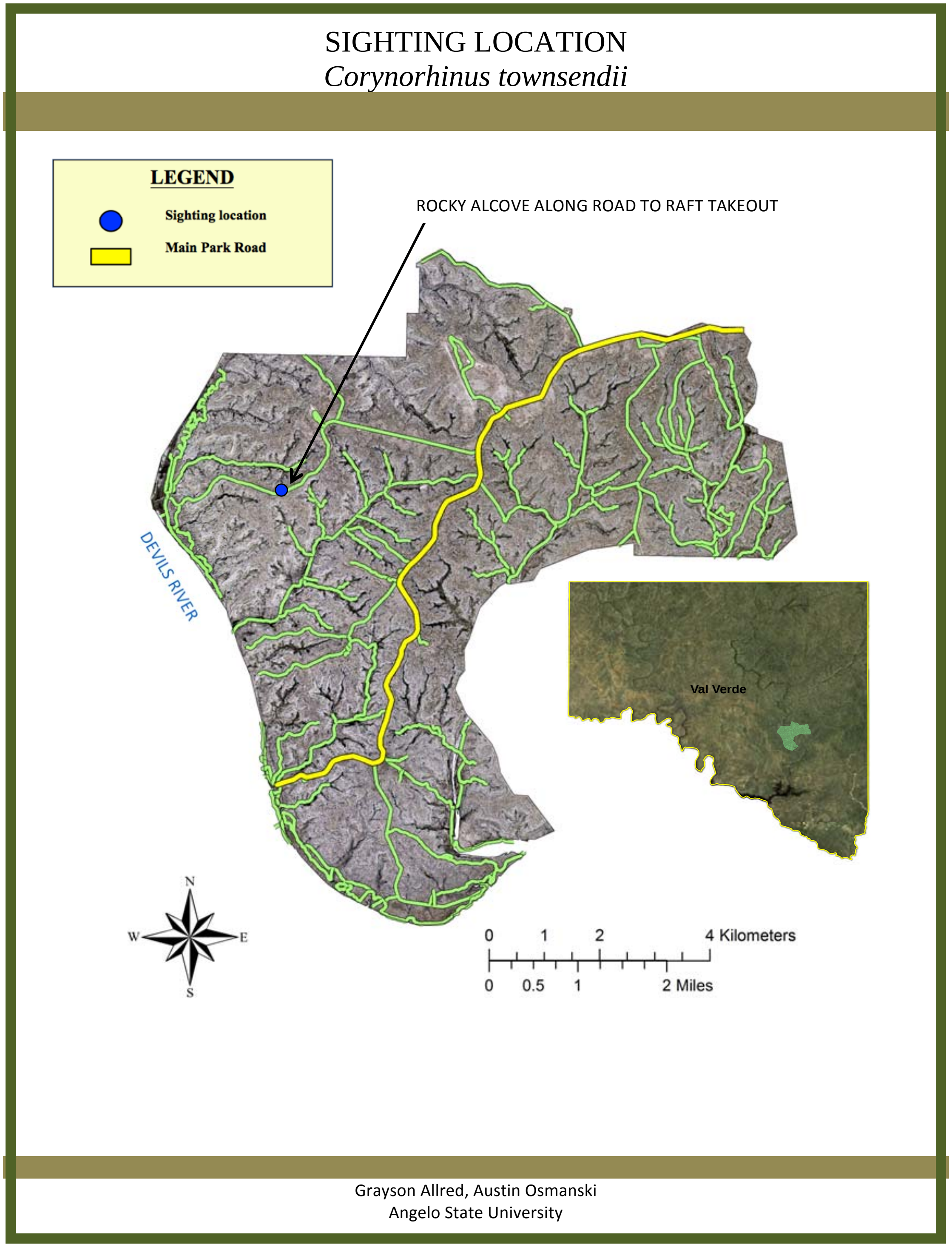

FIG. 19.—Location where *Corynorhinus townsendii* was sighted at DRSNA-DHU.

Townsend's big-eared bat was not encountered frequently at DRSNA-BSU. I did not capture any individuals of this species by mist net, however, one individual was observed in a rocky alcove along the road to the raft takeout (29.72003°N, 101.01430°W; Fig. 19). A second individual was hand captured after my survey dates (Dowler et al. 2016). I acoustically detected *C. townsendii* 15 times at stationary locations (12 detections at Big Satan Canyon, and 3 at North Pool) but did not detect this species on the driving transect. The majority of acoustic detections occurred during spring 2014 (13/15; 86.7%). It was also detected in winter 2013 (2/15; 13.3%).

Antrozous pallidus (Le Conte, 1856) (pallid bat): The echolocation call of pallid bats is short in duration and curves sharply (Fig. 20). It is a FM call of relatively low frequency that begins at about 60 kHz and ends at about 30 kHz. *Antrozous pallidus* uses these calls as it flies within a meter of the ground searching for ground-dwelling insects and scorpions (Adams 2004).

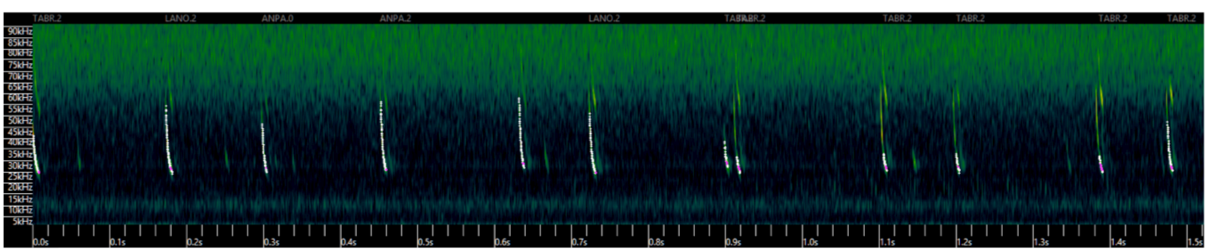

FIG. 20.—Example of echolocation call of *A. pallidus* as seen in Kaleidoscope software (28 Feb 2014; 29.66387°N, 100.95322°W).

In Texas, *A. pallidus* can be found in the following ecoregions: the Chihuahuan Desert, Arizona/New Mexico Mountains, Edwards Plateau, Southern Texas Plains, Central Great Plains, Southwestern Tablelands, and High Plains. This species is considered one of the most plentiful bats of the Trans-Pecos region. According to Ammerman et al. (2012) it inhabits mountainous areas, intermountain basins, and lowland desert scrub habitats at elevations that range from 600 to 2,000 m. Also according to Ammerman et al. (2012), population numbers for this species are significantly lower toward the eastern margin of its range on the Edwards Plateau.

There is not much known about the migratory routines of *A. pallidus*. This species has not been documented during the winter in Texas; however, they have been documented from late March through November. Pallid bats are not known to traverse long distances as they migrate and it is believed that this species hibernates in mines or caves throughout a lot of its summer range (Ammerman et al. 2012).

I encountered the Pallid bat through both traditional and acoustic methods. I captured this species at the North Pool (2 individuals) location (Fig. 2). Pallid bats were acoustically detected on the driving transect only once and 56 times at stationary sites. Most calls of this species (37/56) were detected at Big Satan Canyon. It also was detected at the Lodge (9), North Pool (3), Hill Country Pit (5), and Airstrip (2). The pallid bat was recorded in all seasons of the study period, but almost all of the acoustic detections occurred in either spring 2014 (21/57; 36.8%) or winter 2013 (19/57; 33.3%).

Specimens examined (2): North Pool, 1 male (ASNHC 17601), 1 female (ASNHC 17602), both collected 31 May 2014.

Family Molossidae

Molossid bats range from Canada to Mexico on the North American continent. However, they are most frequently encountered in the southern and southwestern regions of the United States. Four species of molossids have been encountered in Texas, out of seven that are found in the United States (Ammerman et al. 2012).

Nyctinomops macrotis (Gray, 1839) (Big free-tailed bat): Big free-tailed bats have echolocation calls that are similar to the greater mastiff bat. Both species are singularly adapted for open aerial foraging using straight-line pursuit; however, the big free-tailed bat uses a somewhat higher frequency, at times beginning as high as 30 kHz and curving marginally to around 12-17 kHz (Adams 2004; Fig. 21). Nonetheless, their echolocation calls typically have most of their frequency below 20 kHz (Fenton and Bell 1981). Because the calls are at such a low frequency, they are audible to humans (Adams 2004).

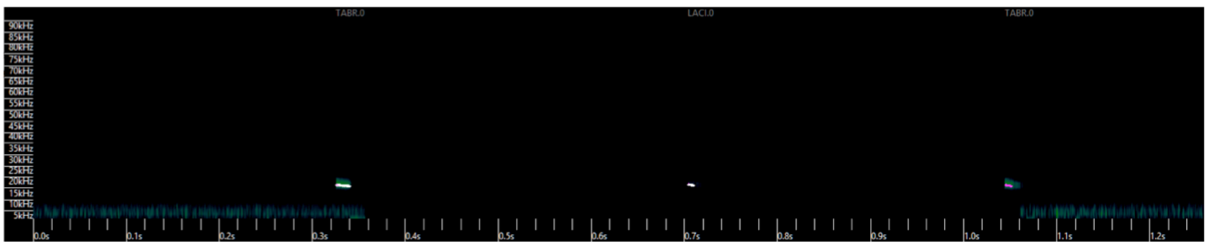

FIG. 21.—Example of echolocation call of *N. macrotis* as seen in Kaleidoscope software (01 Jun 2014; 29.74211°N, 100.91910°W).

In Texas, *N. macrotis* has mainly been documented from the Chihuahuan Desert and the Arizona/New Mexico Mountains ecoregions. It is here that, according to Ammerman et al. (2012) the species seemingly inhabits jagged, rocky terrain in both lowland and highland habitats. These bats have also been encountered in Texas in the following regions: the High Plains, Southwestern Tablelands, Edwards Plateau, East Central Texas Plains, and Gulf Coastal Plains. *N. macrotis* has been known to occur from March to November in Texas.

The big free-tailed bat was not captured during my survey period. However, I did detect this species acoustically twice at Hill Country Pit on 1 June 2014. *Nyctinomops macrotis* has an echolocation call that is quite distinctive and is not likely to be confused with other species. Both acoustic detections of this species occurred during spring 2014. The big free-tailed bat was not detected acoustically via the transect route.

Tadarida brasiliensis (I. Geoffroy Saint-Hilaire, 1824) (Brazilian free-tailed bat): The Brazilian free-tailed bat typically has a flat echolocation call when calling in open space (R. Rodriguez, pers.comm). Other calls of this species have similarities to that of approach phase calls from *Lasionycteris noctivagans* and *Antrozous pallidus* (R. Rodriguez, pers.comm). The call for this species varies between an almost pure constant frequency to that of a sharp, frequency-modulated call. The constant-frequency component of the Brazilian free-tailed bat call begins at about 28 kHz and curves gently to about 25 kHz, whereas the frequency-modulated segments begin at about 60 kHz and curve suddenly to about 25 kHz (Fig. 22). This species pursues moths and other insects using an open aerial straight-line strategy (Adams 2004).

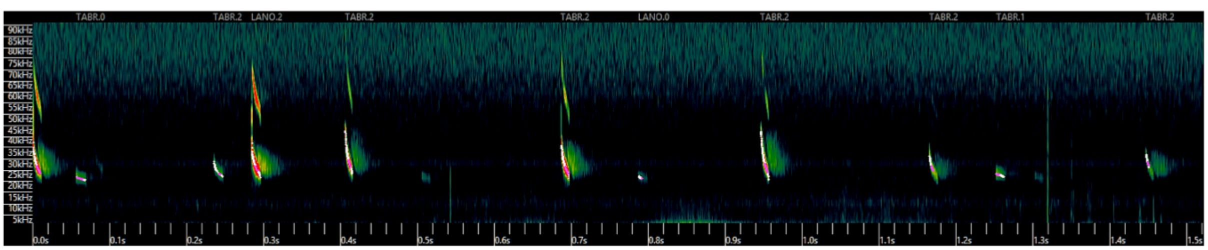

FIG. 22.—Example of echolocation call of *T. brasiliensis* as seen in Kaleidoscope software (28 Sep 2013; 29.67054°N, 100.99875°W).

The range of Brazilian free-tailed bats spans the entire vastness of Texas. They are the most common species of bat in the state. Millions of Brazilian free-tailed bats inhabit a few select caves (known as “guano caves”) each year in Texas. These caves are situated between the Balcones Escarpment and the neighboring Edwards Plateau. In most parts of the state, this species is a seasonal resident. However, they have been known to be a nonmigratory species, and inhabit the eastern part of Texas all year long (Carter 1962; Scales and Wilkins 2007; Spenrath and LaVal 1974). Throughout the rest of the state, it is very unlikely to encounter individuals of this species during winter (Goetze et al. 2003; Yancey 1997).

The Brazilian free-tailed bat was captured at Big Satan Canyon (9 individuals). Additionally, one was found dead at the Summer House on 25 October 2013 (Fig. 26). *Tadarida brasiliensis* was the most common call file detected at stationary sites (169 detections). I detected this species at the following stationary locations: Big Satan Canyon (59), Lodge (45), North Pool (14), Hill Country Pit (12), and Airstrip (39). I also detected *T. brasiliensis* on the driving transect more than any other species (150 detections). Brazilian free-tailed bats were detected in all seasons, but almost half of all acoustic detections for *T. brasiliensis* were recorded during fall 2013 (158/319; 49.5%). There were 39 detections in summer 2014 (12.2%) and 78 detections in spring 2014 (24.5%). Interestingly this species was also the second highest detected species (after *Lasionycteris noctivagans*) during winter 2013 (28/319; 8.8%).

Specimens examined (2): Summer House (29.683850°N, 101.001622°W), 1 individual of unknown sex collected 25 October 2013 (ASNHC 17687); Big Satan Canyon, 1 female collected 28 February 2014 (ASNHC 17612).

SPECIES OF UNVERIFIED OCCURRENCE

Four species of bats representing three families have been recorded from Val Verde County, Texas but were not recorded from DRSNA-DHU. Future research efforts might reveal the presence of these species at DRSNA-DHU.

Order Chiroptera

Family Phyllostomidae

Diphylla ecaudata Spix, 1823 (Hairy-legged vampire): The hairy-legged vampire is native to Central and South American tropical forests and is most frequently encountered in Tamaulipas, Mexico. However, there has been one specimen documented in Texas. This lone female was collected in an abandoned railroad tunnel 19 km west of Comstock in Val Verde County on 24 May 1967 (Reddell 1968). This record was approximately 725 km to the northwest of Tamaulipas, Mexico, extending the range of *D. ecaudata* to the edge of Texas (Ammerman et al. 2012). This was likely a transient individual and there are no established populations in the state.

Family Vespertilionidae

Lasiurus seminolus (Rhoads, 1895) (Seminole bat): *L. seminolus* can be found throughout the southeastern United States. This species is known to occur in 5 physiographic regions in Texas: South Central Plains, Gulf Coastal Plains, East Central Great Plains, Blackland Prairies, Cross Timbers (Ammerman et al. 2012). Recently, however, Brant and Dowler (2000) documented the Seminole bat on the western edge of the Edwards Plateau as well. *Lasiurus seminolus* is chiefly documented in the pine-oak forests of eastern Texas. Though winter records for this species are rare in Texas, and there are none for November or December, it can be found in the state throughout the remainder of the year (Ammerman et al. 2012). I was unable to find a good description of the echolocation call for *L. seminolus*, however it stands to reason that the echolocation call of Seminole bats is very similar to other species of *Lasiurus*, which has a standard “jumping fishhook” shape that varies in frequency.

Lasiurus xanthinus (Thomas, 1897) (Western yellow bat): In the United States, *L. xanthinus* can be found in the southwestern arid region, down the Mexican Plateau west of the Sierra Madre, and in Baja California (Ammerman et al. 2012). The western yellow bat has been documented in the Chihuahuan Desert region of Texas, including Brewster County (Higginbotham et al. 1999) and other locations as far east as Val Verde County (Bradley et al. 1999; Jones et al. 1999; Weyandt et al. 2001). In Texas, this species has been documented in several months of the year: March, June, July, September, October, and November (Ammerman et al. 2012). However, most captures of western yellow bats in the state have occurred in the fall (Ammerman et al. 2012). All of DRSNA-DHU is well within the range of this species and the area provides plenty of appropriate habitat, so it is reasonable to expect this species to occur there. The echolocation call of western yellow bats is very similar to other species of *Lasiurus*, but it is usually more sharply curved than that of the hoary bat (Adams 2004). The sequence for the western yellow bat call is also somewhat more predictable; it typically begins at 60 kHz and ends around 32 kHz. Just like the call of *L. borealis*, the spectrograph of a call from *L. xanthinus* depicts a slight cuplike appearance in some of the vocalizations where the frequency increases slightly at the end (Adams 2004).

Family Molossidae

Eumops perotis (Schinz, 1821) (Western mastiff bat): *Eumops perotis* occupies the jagged, rocky canyon terrain of the dry southwestern United States. This species can be found in Texas along the Rio Grande, where it has been documented in the following counties: Presidio, Brewster, Terrell, and Val Verde. Ammerman et al. (2012) suggested that the western mastiff bat is most likely a stable resident of the Trans-Pecos region of Texas as they have been detected or documented year-round. This is a species of bat that needs a large (>2 m), unobstructed drop from their roost site in order to take flight; therefore they prefer to roost in sites such as rocky cliffs and canyons (Adams 2004). I agree with Brant and Dowler (2001) that the topography along the Devils River provides sufficient roost sites for *E. perotis*. Though DRSNA-DHU is at the northern distributional limit of this species, it does have suitable habitat.

The echolocation calls of the western mastiff bat are of an extremely low frequency. The vocalizations of this species fluctuate slightly and are known to sometimes be constant frequency, as well as frequency modulated (Adams 2004). *Eumops perotis* uses this type of echolocation call as it forages in open areas where there is plenty of room for long-distance, high-speed pursuit that requires little maneuverability. Because the calls are at such a low frequency, they are audible to humans; they begin around 13-14 kHz and curve faintly and gently to about 9 or 10 kHz (Adams 2004).

DISCUSSION

As a result of the acoustical surveying and mist netting, I documented 13 of the 17 bat species that could possibly occur within Devils River State Natural Area-Dan A. Hughes Unit. Nine species were verified by acoustic means and three species by both acoustics and captures (Table 6). One species (*Corynorhinus townsendii*) was documented by acoustic recordings and visual sighting.

TABLE 6.—Bats documented on the Devils River State Natural Area, Dan A. Hughes Unit (July 2013 – Dec. 2014).

Common Name	Species	Documentation Method
Pallid bat	*Antrozous pallidus*	EM3+/ Mist net
Townsend's big-eared bat	*Corynorhinus townsendii*	EM3+/ Visual sighting
Eastern red bat	*Lasiurus borealis*	EM3+
Hoary bat	*Lasiurus cinereus*	EM3+
Silver-haired bat	*Lasionycteris noctivagans*	EM3+
Ghost-faced bat	*Mormoops megalophylla*	EM3+
Cave myotis	*Myotis velifer*	EM3+/ Found dead/ Mist net
Yuma myotis	*Myotis yumanensis*	EM3+
Evening bat	*Nycticeius humeralis*	EM3+
Big free-tailed bat	*Nyctinomops macrotis*	EM3+
Western parastrelle	*Parastrellus hesperus*	EM3+
Eastern perimyotis	*Perimyotis subflavus*	EM3+
Brazilian free-tailed	*Tadarida brasiliensis*	EM3+/ Found dead/ Mist net

Of the seventeen bat species expected to occur in Val Verde County (Schmidly 2004), only four bat species were not identified by either the acoustic or the capture method (*Diphylla ecaudata*, *Eumops perotis*, *Lasiurus xanthinus,* and *Lasiurus seminolus*). It is possible that these four species do not occur at DRSNA-DHU. Three of the four also were not reported at the north unit (all except for *L. seminolus*; Brant and Dowler 2001); however, it is conceivable that *L. seminolus* does appear at DRSNA-DHU since there was a county record of it reported in the survey of the north unit. Overall, the number of bat species documented at DRSNA-DHU is higher than was reported at the Del Norte Unit in 2001 by Brant and Dowler; though, they did not implement an acoustic survey strategy during their study. Brant and Dowler (2001) documented seven species based on capture records while I only captured three species at DRSNA-DHU. It was also notable to confirm the presence of *Nycticeius humeralis* at the Dan A. Hughes Unit because during the previous study at the north unit of DRSRNA there was a range extension documented for the species (Dowler et al. 1999).

Seven species of bat were documented at the Dan A. Hughes Unit that were not documented at the Del Norte Unit (*Corynorhinus townsendii, Lasiurus borealis, Lasionycteris noctivagans, Mormoops megalophylla, Myotis yumanensis, Nyctinomops macrotis,* and *Perimyotis subflavus*). The presence of *M. megalophylla* is especially interesting to note because it was recorded in February. Ghost-faced bats are known to be common winter (Nov. 1 to Mar. 15) residents of caves along the extreme southern edge of the Edwards Plateau, spending the rest of the year in the Chihuahuan Desert region or the Gulf Coastal Plains (Ammerman et al. 2012). DRSNA-DHU is a key juncture between two of these ecoregions and the presence of *M. megalophylla* at the Dan A. Hughes Unit during the winter supports this hypothesis. There were five detections of *Lasiurus borealis* in winter 2013 at Big Satan Canyon, which is curious considering there are few collecting records during winter months and it is thought to only be a summer migrant in the Trans-Pecos region. The presence of *Antrozous pallidus* during winter 2013 is also especially interesting to note because this species has not been documented during the winter in Texas

(Ammerman et al. 2012). These acoustic data represent evidence that at least some pallid bats overwinter in this part of Texas.

I expected that *Tadarida brasiliensis* would be the predominant species detected (via transect and stationary sites combined) because Brazilian free-tailed bats are a common species of bat in Texas and are found statewide (Ammerman et al. 2012). Additionally, their calls are loud and easily detected. It is probable that some of the other species with high acoustic detections (*L. borealis, L. noctivagans, P. subflavus*) will likely be encountered with additional survey efforts (both acoustic and traditional). Though *P. subflavus* is ordinarily considered an eastern species, there have been records from farther west in Texas and into New Mexico (Ammerman 2005, Yancey et al. 1995, Valdez et al. 2009). Because there are not many records of silver-haired bats (*L. noctivagans*) from the summer months, it is consistent with earlier records that this species would have a high detection rate in fall and winter at DRSNA-DHU (Ammerman et al. 2012).

The seasonal variation in species diversity is not surprising since bat populations in Texas decrease in the winter months as the huge numbers of *T. brasiliensis* along with several other species migrate south to Mexico, not to return until spring. Correspondingly, the majority of *T. brasiliensis* were documented in autumn or spring months, as this is when this species would be migrating through the survey region. On the other hand, the majority of the lasiurine bats were documented in the winter months. This makes sense because most lasiurine bats move north in summer (Ammerman et al. 2012). Likewise, the seasonal variation in species activity on the driving transect (higher in fall and spring) was expected because bat activity is thought to decrease in Texas in the winter months.

I was not surprised to find that the results varied between acoustic analysis methods (Software/Quantitative analysis vs. Manual/Qualitative analysis). Kaleidoscope Pro 3.0 is still a relatively new software, and its North American Bat classifier has merely 26 species available, only 11 of which occur in Texas. Of the seventeen species possible at DRSNA-DHU, only eleven are included in the classifier at this point. The fact that not all species are included in the classifier meant that some bat calls analyzed by the software were falsely "pushed" into a species category that was not correct. Also, with the presence of multiple species of *Lasiurus*, call identification can become difficult with much overlap among species (Ammerman et al. 2008). This could have further affected the software analysis, causing false identifications of some lasiurine species. At this point, I have more confidence in the manual analysis of calls recorded at DRSNA-DHU. However, with both acoustic analysis methods (qualitative and quantitative) there were a high number of call files that could not be classified (NoID) due to partial or reduced recordings of the bat call (264 from stationary sites and 729 call files from driving transects; Table 2). The proportion of noise files to total files recorded (8,450/10,085; 23% from stationary, 77% from driving transects) was comparable to similar studies (Allen et al. 2011), but was noticeably higher in the driving transect due to road, engine, and insect noise.

Some species-specific trends were apparent among seasons. Pallid bats, eastern red bats, and Brazilian free-tailed bats, were the most ubiquitous bat species throughout the year, occurring during all seasons of the survey period (based on calls recorded via the transect and at stationary sites). This distribution may be attributed to their ability to migrate during the year. Still, some variation in Brazilian free-tailed bat activity did occur among seasons. Based on call activity, Brazilian free-tailed bat activity was highest during fall 2013, for both the transect and at stationary sites. *Tadarida brasiliensis* activity was relatively low during winter 2013 for both the transect and at stationary sites; however, at stationary sites, oddly it was lowest in fall 2014. This was unusual because fall is a time of year when numbers of Brazilian free-tailed bats are expected to be relatively high. It is also unusual because the highest activity during the study period was recorded during fall 2013 for this species.

Of the thirteen species of bats sampled at DRSNA-DHU, the three lasiurine species showed seasonal activity peaks in the cooler portions of the year based on call data. The two-molossid bats, *Tadarida brasiliensis* and *Nyctinomops macrotis*, showed seasonal activity peaks in the warmer portions of the year. The other seven vesper bat species had seasonal activity peaks that fluctuated throughout the year. This is not unexpected as bats from this group exhibit a wide range of behaviors. Some vesper species stay in the same general area year round, often hibernating underground or in caves during the coldest months. While other species of this group migrate (Ammerman et al. 2012).

MANAGEMENT RECOMMENDATIONS AND FUTURE WORK

Based on my survey of bat activity and diversity using traditional sampling (mist nets) and acoustic monitoring, I recommend that the Texas Parks and Wildlife Department promotes and/or maintains wetland habitats as foraging areas for bat communities at Devils River State Natural Area – Dan A. Hughes Unit. Exposed sources of water are vital to bat populations. They allow access to drinking water as well as provide areas with large insect populations for bat species that forage (Korine et al. 2016). It is also critical to maintain woodland habitat for bat species that roost in tree foliage or bark (*L. borealis*, *L. cinereus*, and *N. humeralis* among others; Kunz 1982). I also advocate that park personnel leave dead snags in place to serve as potential cavity roosts for bats, as well as other wildlife, similar to the recommendation Ammerman et al. (2008) made regarding bat diversity and activity among Texas Army National Guard sites. For future conservations efforts, TPWD personnel at the Dan A. Hughes Unit might also consider placing bat boxes (Tuttle and Hensley 1993) to benefit the bat community. Bat boxes serve as alternative roost sites for species that prefer crevices and are known to inhabit bat houses (*Myotis velifer*, *Tadarida brasiliensis*, and *Nycticeius humeralis*; Harvey et al. 2011). Although I did not find any natural roost sites during my survey period, *Corynorhinus townsendii* was spotted in a shallow, cave-like structure in the side of a cliff-face at night. This suggests that at the very least, some bat species use the natural terrain of DRSNA-DHU as temporary “resting” locations during foraging.

There are several aspects of this survey that deserve further examination. First, more frequent and more extensive sampling (both traditional and acoustic) across DRSNA-DHU could likely uncover other bat species. Concentrated sampling in the summer would increase understanding of the bat fauna at DRSNA-DHU. Additionally, more complete survey efforts during fall and spring across the park would increase the likelihood of documenting other migratory bats at DRSNA-DHU. Furthermore, future research at the park should include systematic re-sampling through the combination of mist net surveys at established water sources (especially at Big Satan Canyon, Hill Country Pit, and North Pool) with stationary acoustic surveys to monitor long-term trends in bat communities, similar to the methods implemented by Ammerman et al. (2008) and to the recommendation they made regarding bat diversity and activity among Texas Army National Guard sites. Determining bat species presence from acoustic call files will, however, require manual analysis as long as the North American Bat classifier of the Kaleidoscope software does not include all of the species found at DRSNA-DHU. I advocate caution with the use of driving transects for long-term monitoring at DRSNA-DHU. While this can be a relatively easy and stress-free survey method, the number of noise files is excessive and several species (*C. townsendii, M. megalophylla, M. velifer, M. yumanensis,* and *N. macrotis*) that were detected at stationary locations were not detected on the driving transect. For future acoustic monitoring at DRSNA-DHU involving driving transects, I recommend the use a directional microphone paired with an acoustic monitoring device to decrease the amount of noise recorded. Devils River State Natural Area- Dan A. Hughes Unit is a diverse location and is an important conservation zone for the state of Texas as well as the southwestern United States. It is likely that additional species will be identified in the park area and a more complete understanding of the seasonal fluctuations in bat populations will be attained through continued research effort.

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APPENDIX 1

Voucher specimens collected at Devils River State Natural Area, Dan A. Hughes Unit (July 2013 – Dec. 2014). Species: ANPA = *Antrozous pallidus,* MYVE = *Myotis velifer*, TABR = *Tadarida brasiliensis*. Location: BSC = Big Satan Canyon, NP = North Pool.

Date	Species	Sex	Location	Collection method	Catalog Number
20 Jul 2013	MYVE	Male	Big Satan Canyon	Found dead	ASNHC 17686
25 Oct 2013	TABR	Unknown	Summer House	Found dead	ASNHC 17687
28 Feb 2014	TABR	Female	Big Satan Canyon	Mist net	ASNHC 17612
11 Apr 2014	MYVE	Male	North Pool	Mist net	ASNHC 17607
12 Apr 2014	MYVE	Male	North Pool	Mist net	ASNHC 17606
17 May 2014	MYVE	Female	Big Satan Canyon	Mist net	ASNHC 17604
31 May 2014	ANPA	Male	North Pool	Mist net	ASNHC 17601
31 May 2014	ANPA	Female	North Pool	Mist net	ASNHC 17602
31 May 2014	MYVE	Male	North Pool	Mist net	ASNHC 17608

APPENDIX 2

Bat captures via mist net at Devils River State Natural Area, Dan A. Hughes Unit (July 2013 – Dec. 2014). Species: ANPA = *Antrozous pallidus*, MYVE = *Myotis velifer*, TABR = *Tadarida brasiliensis*. Reproductive status: Preg = pregnant, NR = non-reproductive, Lact = lactating. Location: BSC = Big Satan Canyon, NP = North Pool. Catalog Number: N/C = not collected.

Date	Species	Time (12 hr)	Weight (g)	Age	Sex	Reproductive Status	Forearm (mm)	Location	Catalog Number
28 Feb 2014	TABR	9:30 pm	13	Adult	Female	Preg	43.2	BSC	ASNHC 17687
11 Apr 2014	MYVE	9:50 pm	10	Adult	Male	NR	43	NP	ASNHC 17607
12 Apr 2014	MYVE	10:45 pm	10	Adult	Male	NR	44.1	NP	ASNHC 17606
17 May 2014	MYVE	9:30 pm	11	Adult	Female	Preg	42.3	BSC	ASNHC 17604
17 May 2014	TABR	9:30 pm	11	Adult	Female	Preg	43.4	BSC	N/C
17 May 2014	TABR	9:45 pm	13	Adult	Female	Preg	44.4	BSC	N/C
17 May 2014	TABR	10:00 pm	13	Adult	Female	Preg	42.7	BSC	N/C
17 May 2014	TABR	10:15 pm	15	Adult	Female	Preg	41.5	BSC	N/C
17 May 2014	TABR	10:20 pm	13	Adult	Female	Preg	43.0	BSC	N/C
17 May 2014	TABR	10:40 pm	16	Adult	Female	Preg	41.9	BSC	N/C
17 May 2014	TABR	10:55 pm	13	Adult	Female	Preg	45.6	BSC	N/C
17 May 2014	TABR	11:18 pm	11	Adult	Female	Preg	42.2	BSC	N/C
31 May 2014	ANPA	11:00 pm	13	Adult	Male	Scrotal	49	NP	ASNHC 17601
31 May 2014	ANPA	11:00 pm	17.5	Adult	Female	Lact	53.9	NP	ASNHC 17602
31 May 2014	MYVE	11:00 pm	11.5	Adult	Female	Lact	42.2	NP	N/C
31 May 2014	MYVE	11:00 pm	12	Adult	Female	Lact	45.1	NP	N/C
31 May 2014	MYVE	11:45 pm	10	Juvenile	Male	NR	43.6	NP	ASNHC 17608
31 May 2014	MYVE	11:45 pm	13.5	Adult	Female	Lact	44.5	NP	N/C
01 Jun 2014	MYVE	12:10 am	13.5	Adult	Female	Lact	43.7	NP	N/C

APPENDIX 3

Bat echolocation call files recorded at Devils River State Natural Area, Dan A. Hughes Unit based on acoustic data from manual analysis (July 2013 – Dec. 2014). Location: BSC = Big Satan Canyon, NP = North Pool, HCP = Hill Country Pit.

Date	Location	Total	ANPA	COTO	LABO	LACI	LANO	MOME	MYVE	MYYU	NYHU	NYMA	PAHE	PESU	TABR	NOID
21 Jul 2013	Lodge	73	6	0	3	0	0	0	8	0	3	0	13	34	5	1
27 Sep 2013	Transect	112	0	0	0	0	7	0	0	0	0	0	0	0	101	4
28 Sep 2013	Lodge	89	3	0	10	0	10	0	3	0	5	0	5	0	40	13
26 Oct 2013	Transect	5	0	0	0	0	0	0	0	0	0	0	0	0	2	3
15 Nov 2013	Transect	29	0	0	0	0	3	0	0	0	0	0	0	0	2	24
20 Dec 2013	Transect	13	0	0	0	0	0	0	0	0	0	0	0	0	13	0
24 Jan 2014	Pila	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24 Jan 2014	Transect	12	0	0	0	0	0	0	0	0	0	0	0	0	0	12
25 Jan 2014	Transect	2	0	0	0	0	0	0	0	0	0	0	0	0	1	1
08 Feb 2014	BSC	70	0	2	4	13	9	0	2	0	0	0	11	14	14	1
28 Feb 2014	BSC	101	19	0	1	0	63	1	2	0	0	0	0	2	13	0
28 Feb 2014	Transect	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3
28 Mar 2014	Transect	8	0	0	1	0	1	0	0	0	2	0	0	0	3	1
11 Apr 2014	NP	32	0	0	0	1	5	0	0	2	2	0	8	12	2	0
11 Apr 2014	Transect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 Apr 2014	NP	21	0	0	0	0	1	0	0	0	6	0	0	8	2	4
12 Apr 2014	Transect	7	0	0	0	0	0	0	0	0	0	0	0	0	3	4
16 May 2014	NP	2	0	0	0	0	0	0	0	0	0	0	0	0	1	1
16 May 2014	Transect	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
17 May 2014	BSC	98	18	10	0	2	34	0	0	0	1	0	0	1	32	0
17 May 2014	Transect	16	0	0	0	0	0	0	0	0	0	0	0	0	5	11

Date	Location	Total	ANPA	COTO	LABO	LACI	LANO	MOME	MYVE	MYYU	NYHU	NYMA	PAHE	PESU	TABR	NOID
18 May 2014	NP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 May 2014	Transect	7	0	0	0	0	0	0	0	0	0	0	0	0	5	2
31 May 2014	NP	348	3	3	34	0	13	0	87	10	42	0	61	86	9	0
31 May 2014	Transect	6	0	0	0	0	2	0	0	0	0	0	0	0	4	0
01 Jun 2014	HCP	46	0	0	1	0	2	0	11	0	4	2	7	8	11	0
01 Jun 2014	Transect	2	0	0	0	0	0	0	0	0	1	0	0	0	1	0
18 Jul 2014	Transect	5	1	0	0	0	0	0	0	0	0	0	0	0	0	4
26 Jul 2014	Airstrip	83	2	0	3	2	35	0	0	0	0	0	0	0	39	2
27 Jul 2014	Transect	9	0	0	0	0	0	0	0	0	0	0	0	0	0	9
16 Aug 2014	Transect	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5
31 Aug 2014	Transect	136	0	0	0	0	0	0	0	0	0	0	0	0	0	136
30 Sep 2014	Transect	45	0	0	0	1	25	0	0	0	2	0	0	0	6	11
17 Oct 2014	Transect	2	0	0	0	0	1	0	0	0	0	0	0	1	0	0
17 Oct 2014	HCP	187	5	0	15	0	29	0	105	6	0	0	26	0	1	0
24 Oct 2014	Transect	12	0	0	3	0	6	0	0	0	1	0	0	0	0	2
24 Nov 2014	Transect	16	0	0	0	0	3	0	0	0	0	0	0	0	4	9
11 Dec 2014	Transect	3	0	0	0	0	0	0	0	0	0	0	2	0	0	1